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A CRITICAL REVIEW OF THE WORLD LITERATURE IN APPLIED MECHANICS AND RELATED ENGINEERING SCIENCE

REVS. 1145–1457 VOL. 6, NO. 4 APRIL 1953

GENERAL

Theoretical and Experimental Methods.. 171
Mechanics (Dynamics, Statics, Kinematics) 174

MECHANICS OF SOLIDS

Gyroscopics, Governors, Servos..... 175
Vibrations, Balancing..... 175
Wave Motion, Impact..... 176
Elasticity Theory..... 177
Experimental Stress Analysis..... 177
Rods, Beams, Shafts, Springs, Cables, etc. 178
Plates, Disks, Shells, Membranes..... 179
Buckling Problems..... 180
Joints and Joining Methods..... 181
Structures..... 181
Rheology (Plastic, Viscoplastic Flow)... 185
Failure, Mechanics of Solid State..... 188
Material Test Techniques..... 191
Mechanical Properties of Specific Materials..... 191
Mechanics of Forming and Cutting.... 194

MECHANICS OF FLUIDS

Hydraulics; Cavitation; Transport.... 195
Incompressible Flow: Laminar; Viscous.. 196
Compressible Flow, Gas Dynamics.... 198
Turbulence, Boundary Layer, etc..... 201
Aerodynamics of Flight; Wind Forces.. 203
Aeroelasticity (Flutter, Divergence, etc.) 203
Propellers, Fans, Turbines, Pumps, etc... 203
Flow and Flight Test Techniques..... 204

HEAT

Thermodynamics..... 204
Heat and Mass Transfer..... 206

MISCELLANEOUS

Acoustics..... 208
Ballistics, Detonics (Explosions)..... 210
Soil Mechanics, Seepage..... 210
Micromeritics..... 212
Geophysics, Meteorology, Oceanography..... 212
Lubrication; Bearings; Wear..... 214
Marine Engineering Problems..... 216

Communications, 170

Recent Work on Kinematics, O. Bottema, 169

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APPLIED MECHANICS REVIEWS

VOL. 6, NO. 4 MARTIN GOLAND *Editor* APRIL 1953

RECENT WORK ON KINEMATICS

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KINEMATICS can perhaps be best defined as the study of the motion (trajectory, velocity, acceleration) of the points of a moving rigid body. It would be a common chapter of general mechanics but for the fact that often the motion of the body is determined by the circumstance that one or more of its points have prescribed paths due to their belonging to other moving rigid bodies, which are linked in some way with the one in question. In view of this, kinematics has many contacts with the theory of linkages and mechanisms and, as a matter of fact, it seems impossible to trace the border line between the two subjects.

The study of kinematics started in the second half of the 19th century, and the name of Burmester is the first one to be mentioned. The more mathematical side of the geometry of motion was brilliantly developed by the French school (Mannheim, Darboux, Koenigs) and had eminent representatives in England (Cayley, Roberts, Ball). Independent of their work was a development in Russia, starting with Chebíshev, who was very interested in the theory of mechanisms.

Kinematics is studied either for its own sake as an attractive pure science, or for its applications in engineering. The latter point of view is emphasized in the technological universities of Germany and Austria; many textbooks on "Getriebelehre" deal with kinematics as a necessary introduction, and sometimes, in a course of descriptive geometry, place is given to constructions of "kinematical geometry."

Though kinematics is not a new chapter of science, nor a very extensive one in itself, interesting work is always being done in this field. We shall try to give in a few lines an impression of the topics of the later years. It is altogether out of the question to be in any sense complete, the number of publications in, say, the last ten years being at least several hundred. Moreover, there is much incidental work; there are no main problems to be fought with, and it is impossible to do justice to everyone's investigations. We leave out of this account all work on differential geometry done with kinematical considerations, such as the use of Darboux's method of the moving trihedron. Blaschke's highly original work in this field was continued and summarized (1).[1]

Of the books published in recent years we mention those of Garnier (2), Beth (3), and Hain (4). Each is of a very different character. The first is in the style of the best French tradition, remarkable for its elegant exposition, precise definitions, and rigorous proofs. It makes use of analytical (and vectorial) methods. The third volume deals with kinematics in non-Euclidean space and it seems unlikely that its results will be of interest for practical applications. The work of Beth is based on direct geometrical reasoning; it contains an original representation of the positions of a moving plane on the points of three-dimensional space, which may improve the reader's insight into the problems and be useful for a classification of motions. Hain's book has many chapters on kinematics as an introduction to the theory and practice of mechanisms and, therefore, meets the engineer's wishes best; it has, moreover, an extensive bibliography.

On the general theory of kinematics in the plane, we mention the work of Steward (5) and of Bereis (6), who derive the classical results by means of the complex variable; a paper by van der Woude (7) dealing with a new "remarkable point" related to that of Ball; and work of Karas (8) and Rosenauer (9) on acceleration constructions. Also, time and again we meet new proofs of well-known theorems, such as those of Euler-Savary, which always remains an engaging subject. Of the special motions in the plane, that of the bar CD of the moving quadrilateral ABCD with the fixed points A and B plays an ever-important part in the interests of the people concerned. The motion is by no means a simple one, the three-bar curve being of the sixth degree; in parametric form it can only be described by elliptic functions. A monograph on the curve giving a survey of the investigations of the past decades was written by Groenman (10). As Alt showed in 1921, there is another problem in kinematics which leads to a (special) three-bar curve; a paper on this curve was published by Dizioglu (11). A generalization of the three-bar motion is the subject of a publication by Hackmuller (12), where once again complex numbers are shown to be useful. Meyer zur Capellen (13) wrote about the three-bar curves of the twin mechanism.

The complicated analytical theory of the three-bar curve has undoubtedly kept the engineer from using it, and we fully understand the publication of an atlas by Hrones and Nelson (14) containing thousands of trajectories which must be very useful in many design problems.

Long ago the properties of curves generated by kinematical methods were a fruitful field of research for geometers. Not much is done in this line nowadays. We mention Wunderlich's papers on a generalization of the cycloid (15).

Obviously, no new things can be said about the very important but well-known elementary plane motions (elliptic motion, cardioid motion, and so on) which serve as examples for the theory

[1] Numbers in parentheses indicate References listed at end of the paper.

in every textbook. But a problem has risen in later years in relation to them. One may ask if a certain general motion considered at a given moment can be approximated by an "osculating" elementary motion, in this way generalizing the theorem that every motion at any moment can be approximated by a rotation (or translation). Until now there have been investigations for elliptic motion only; an instantaneous position of the moving plane which osculates a suitably chosen elliptic motion is called a "Cardan position." There was at first some uncertainty about the definition of "osculating," but the matter now seems settled (16, 17, 18, 19).

Kinematics in three-dimensional space is incomparably more difficult than that in the plane. (We do not mention the kinematics in N-dimensional space on which some work appeared in later years.) As an illustrative instance, we mention the some hundred-years-old Euler-Savary formula for the curvature of a plane trajectory, which extension to space has shown to be a most challenging problem. It seems unnecessary to give a complete survey of the papers on the subject because, in 1940, Garnier (2) succeeded in giving a very satisfactory solution; this is included in the second volume of his work and turns out to be less complicated than might be expected. It embraces the results for the plane and sphere as special cases.

There are some kinds of motion of three-dimensional space which remain in the limelight. If the system moves so that one of its lines coincides with itself and one of its points moves on a given plane, we have Darboux's motion; all trajectories are ellipses. For this "upright elliptic motion" we refer to Strubecker (20) and Krames (21).

Another motion seems still more fascinating. Nearly half a century ago Bennett proved that a skew quadrilateral ABCD with hinges in the vertices so that the axes of the rotation are perpendicular to the planes through the adjacent sides will be rigid except when AB = CD, BC = DA. The motion of this "isogram" gives rise to a great number of geometrical and kinematical theorems. MacMillan (22) and Andress (23) contributed to the theory, and the mechanism has the special attention of Goldberg (24) who wrote papers on this and related subjects.

With the last remark we reach the border of kinematics proper and we meet the chapter on linkages. There is a general theorem due to Grübler which deals with the number of degrees of freedom contained in a given system, and of which we have counted some three or four proofs published in the past four years. Much work is done on plane linkages and mechanism; this is useful and interesting, but impossible to summarize here. We draw attention to what is called the synthesis of mechanisms, a discipline developed in Germany and of which Hain's book (4) gives a good idea. The author himself has made many contributions, of which his method of "point-position-reduction" is worthy of note.

Theoretical work on mechanisms in three dimensions by analytical methods is often cumbersome, and—as one of the experts puts it—"that is probably a congenital feature of the problems in spatial linkages." Recognizing the omission of much other valuable work from this survey, we call attention to a very readable paper of Poritsky and Dudley (25) on helical gears.

The aforesaid statements are far more incomplete than is justified, merely by the editorial space limitations imposed. Roughly speaking, half of the publications on the subject are not accessible to a worker who is unfamiliar with the Russian language and who has to satisfy himself with the (much appreciated) abstracts in APPLIED MECHANICS REVIEWS and *Mathematical Reviews*. In Chebíshev's native country, a great deal of work is done in honor of this scientist by republication and discussion of his papers, and by further development of his ideas. Nearly all the foregoing subjects touched upon are cultivated, and there are, moreover, some topics characteristic of his school; e.g., the classification of linkages and the error analysis of approximate methods in the synthesis of mechanisms.

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Communications

Concerning AMR 5, Rev. 2699 (Sept. 1952): B. Mazelsky, Numerical determination of indicial lift of a two-dimensional sinking airfoil at subsonic Mach numbers from oscillatory lift coefficients with calculations for Mach number 0.7.

Also, AMR 5, Rev. 2920 (Oct. 1952): B. Mazelsky, Determination of indicial lift and moment of a two-dimensional pitching airfoil at subsonic Mach numbers from oscillatory coefficients with numerical calculations for a Mach number of 0.7.

Reviewer asserts in first review, (a) "numerical values do not form a logical variation, etc."; (b) he believes reciprocal relations used (those given by Garrick) are incorrect, thereby implying the results of the paper are not only numerically wrong, but also have a wrong basis.

Reviewer asserts in the second review that reciprocal relations are "slightly" in error and that a relation given by him is the exact one. It is appropriate to attempt to resolve the differences between the reciprocal relations used by the author and those the reviewer asserts are "correct."

One form for expressing the indicial function $k_1(s)$ in terms of the complex harmonically oscillating function $F(k) + iG(k)$ is

$$k_1(s) = F(0)\, l(s) + (1/2\pi) \int_{-\infty}^{\infty} \{[F(k) - F(0)] \sin ks/k + G(k) \cos ks/k\} dk \quad [1]$$

where

$$l(s) = 1 \text{ for } s > 0$$

$$l(s) = 0 \text{ for } s < 0$$

For the case when $s > 0$

$$\int_{-\infty}^{\infty} \sin ks\, dk/k = \pi$$

and Eq. [1] becomes

$$k_1(s) = F(0)/2 + (1/2\pi) \int_{-\infty}^{\infty} [F(k) \sin ks/k + G(k) \cos ks/k] dk; \quad s > 0 \quad [2]$$

If use is made of the property

$$F(-k) = F(k) \quad [3]$$

$$G(-k) = -G(k)$$

then

$$k_1(s) = F(0)/2 + (1/\pi) \left[\int_0^{\infty} F(k) \sin ks/k\, dk + \int_0^{\infty} G(k) \cos ks/k\, dk\right]; \quad s > 0 \quad [4]$$

Eq. [4] is essentially the result the reviewer asserts should replace the "incorrect" relation used by the author. Eq. [4], although correct, is a special form of the reciprocal relations derived by Garrick and used by the author. If the condition that $k_1(s) = 0$ for $s > 0$ is included in the development of Eq. [4], then Garrick's result follows immediately.

Substitution of $-s$ for s in Eq. [1] together with the conditions

$$k_1(-s) = 0$$

$$l(-s) = 0$$

results in the expression

$$0 = (F(0)/2\pi) \int_{-\infty}^{\infty} \sin ks\, dk/k - (1/2\pi) \int_{-\infty}^{\infty} F(k) \sin ks\, dk/k + (1/2\pi) \int_{-\infty}^{\infty} G(k) \cos ks\, dk/k \quad [5]$$

If Equations [2] and [5] are combined and use is again made of Equation [3], the following reciprocal relations are obtained when $s > 0$

$$k_1(s) = F(0) + (2/\pi) \int_0^{\infty} G(k) \cos ks\, dk/k; \quad s > 0 \quad [6a]$$

and

$$k_1(s) = (2/\pi) \int_0^{\infty} F(k) \sin ks\, dk/k; \quad s > 0 \quad [6b]$$

Equation [6] is the result obtained by Garrick when the steady-state response is unity ($F(0) = 1$), and forms the basis of the results obtained in the two reviews.

In the numerical evaluation of the $k_1(s)$ function at subsonic Mach numbers, it was found that Equation [6b] led to more accurate results and consequently was used throughout the analysis. The author believes that if the reviewer's special form of the reciprocal relations were used, the results would not be as accurate.

The author can find no logical basis for the reviewer's statement that "the numerical values for k_1 at $M = 0.7$ do not form a logical variation, etc." B. Mazelsky, USA

Concerning AMR 6, Rev. 350 (February 1953), Westcott, J. H., The development of relationships concerning the frequency band width and the mean square error of servo systems from properties of gain-frequency characteristics.

Line 7 should read: "...has a constant value of unity up to some cut-off frequency..."

Theoretical and Experimental Methods

(See also Revs. 1170, 1178, 1185, 1305, 1433)

1145. Willers, F. A., Mathematical machines and instruments [Mathematische Maschinen und Instrumente], Berlin, Akademie-Verlag, 1951, xii + 318 pp. $8.16.

Part of this book constitutes a very complete treatise on slide rules, planimeters, hodographs, harmonic analyzers, and other small instruments for carrying out mathematical operations. The remainder contains a very incomplete description of the modern automatic digital computing machines.

Essentially, this is a revised edition of "Mathematical instruments" by the same author, published in 1943. The change in title is meant to indicate the increased importance to which digital machines have grown in recent years. (Author uses the word "machines" for digital computers; "instruments" for analog computers.) In further recognition of this growth, a good deal of material on digital machines, especially the large automatic ones, has been added. But recent developments in the digital field have been so rapid that it would have been impossible to treat them in as much detail as the older subjects, without doubling or trebling the size of the book. The result is a strangely heterogeneous work. About the small instruments mentioned above, the book contains all the information anyone could desire, while the treatment of the large digital machines is so meager and so out of date that it can be used at most as a preliminary introduction to the subject, and even for that purpose, other books are better suited. There is a good chapter on desk-type calculators; understandably it deals mostly with European makes, but this limitation is not serious, as the differences between American and European machines are not significant. There is also an adequate description of differential analyzers of the Vannevar Bush type, but the electronic differential analyzers, which today are far more widely used, are hardly mentioned. No mention at all is made of the various special-purpose machines such as linear-equation solvers. F. A. Alt, USA

1146. Clarke, L. N., The effect of the number of sections on the accuracy of a particular RC electrical analogue, *Austral. J. appl. Sci.* **3, 2, 119–124, June 1952.**

The use of an RC electrical analog with lumped constants is examined for investigating certain errors in a dynamic method of measuring thermal constants. A mathematical analysis of the multisection analog shows that more than 20 sections are necessary to obtain the required accuracy over the time interval of interest in the thermal experiment. It is concluded that an analog requiring so many sections is not economical because of the necessity of obtaining a large number of condensers with very high leakage resistances.

From author's summary by F. A. Willers, Germany

1147. Schreier, O., and Sperner, E., Introduction to modern algebra and matrix theory, New York, Chelsea Publ. Co., 1951, viii + 378 pp. $4.95.

This excellent book—a combination and rearrangement, in translation, of "Einfuhrung in die Analytische Geometrie und Algebra" and the earlier "Vorlesungen über Matrizen"—should

be a welcome addition to the list of English language texts in the border area which joins algebra and geometry. Although the treatment seems, to the reviewer, not quite "Modern" in the sense of Albert, Birkhoff, and others, it is modern-with-a-small-m, and quite stimulating. Order of development departs from that employed in more conventional presentations, but the ordering permits motivation of development which is exploited throughout, and strikes the reviewer as one of the strong points of the book. Development of the determinant from the volume concept is a good example of the method and its effective use. The book is divided into five chapters headed: Affine space, Linear equations; Euclidean space, Theory of determinants; Field theory, The fundamental theorem of algebra; Elements of group theory; Linear transformations and matrices. L. B. Hedge, USA

1148. Gelfond, A. O., Calculus of finite differences [Ischisleniye konechnikh raznosteĭ], Moscow-Leningrad, Gosud. Izdat. Tekh.-Teor. Lit., 1952, 479 pp.

Book is designed for students of mathematical, physical, and technical faculties of the Russian universities. It has five chapters and explains material important not only from the theoretical point of view, but also for approximate computations (numerical integration, solving of differential and integral equations of applied science, etc.).

Book contains, in addition to usual questions occurring in works of this kind, many special problems which are difficult to find in the literature; e.g., considerations about differential equations of infinite order, about finite differences for the case of complex variables, and others.

The last chapter deals with difference equations and is of special significance for technical use. The book discussed, although of mathematical character, can be recommended to technicians just because of sections important in applied science and not easily available to engineers.

V. Vodička, Czechoslovakia

1149. Plunkett, R., On the rate of convergence of relaxation methods, *Quart. appl. Math.* **10,** 3, 263–266, Oct. 1952.

For hand computers, relaxation methods of solving partial differential equations are much faster than systematic iteration, since the computer can apply his experience in deciding at each stage what to do next. Something like relaxation may be programmed for an automatic digital computer by formalizing the decisions which have to be made in choosing the next step, and by including appropriate operations in the program. Author shows, however, that these extra operations take so long that, in most cases, the method is no faster than systematic iteration.

M. V. Wilkes, England

1150. Bückner, H., Numerical methods on the solution of integral equations [Die praktische Behandlung von Integralgleichungen], Berlin, Springer-Verlag, 1952, iv + 127 pp. DM 18.60.

Author presents a systematic and up-to-date outline of the principal ideas and methods on the numerical solution of integral equations. He emphasizes that developments in this domain of mathematics are still in a rather dynamic and changing state. Book is principally concerned with the "linear integral equations of the second kind," also called "Fredholm integral equations," which show greatest promise in the perspective of numerical analysis. Principal methods and ideas may, however, to a certain extent also be extended to the "linear integral equations of the first kind," or the so-called "Volterra integral equations."

A great number of numerical procedures for the practical solution of integral equations may be classified as belonging to one of two principal methods of attack: (a) *Iteration Procedures*, analogous to the iterative methods used in the theory of differential equations; (b) methods based on the principle of *substitution* of approximation kernels of simple mathematical structure replacing the actual kernel of the equation.

Investigations are restricted principally to integral equations of the type $y(s) = \lambda \int_a^b K(s, t)\, y(t)\, dt + f(s)$ with the restriction imposed that both the *disturbance* $f(s)$ and the *kernel* $K(s, t)$ are continuous in the respective intervals, namely, for $f(s)$, $a \leq s \leq b$, and for $K(s, t)$, $a \leq s \leq b$, $c \leq t \leq d$, except at a finite number of points.

Investigations are carried through five main chapters. Chapter I begins with a condensed outline of the well-known Fredholm theory of integral equations, discusses the zeros of the Fredholm determinants, the reciprocal kernel, and the most important types of operators of the integral equation theory. Chapter II discusses the determination of eigenvalues by means of principles of the calculus of variations and by means of so-called restriction theorems ("Einschliessungssaetze"). Four basic restriction theorems are deduced and restriction polynomials developed. Purpose and value of these theorems are an approximative prediction of the position of the reciprocal eigenvalues. Chapter III broadly treats the most well-known iteration procedures for numerical solution of integral equations. Problem of convergence of classical iteration methods is investigated. First, eigenvalues of kernels are computed and higher-order eigenvalues are separated, by iterative procedures in both cases. Iteration methods have great importance from the practical point of view. Of even greater importance may be the substitution procedures which are comprehensively treated in chapter IV. Substitution applies to both the kernel and the disturbance of the integral equation. The disturbance $f(s)$ may be replaced by a finite sum of elementary built terms, and the kernel $K(s, t)$ may be approximated by a finite sum of products of two functions, one factor being a function of s alone, and the other being a function of t. Basic ideas of a theory of error estimation concerned with the validity of the approximations are outlined. Specific approaches falling into this chapter are the method of Ritz and the analogy methods, which are closely related to Fredholm's own theory and are based on the fundamental idea of replacing the integral equation by a system of common linear equations; the integral equation in this perspective may be conceived as the limiting equation of a linear equation system in n unknowns for $n \to \infty$. As another main idea, the elements of the Hilbert theory of eigenvalues and eigenfunctions of real symmetrical kernels are developed. Chapter V concludes the book with some interesting remarks on kernels of specific structure and a discussion of the specific Volterra integral equation $Y(s) + \int_0^s K(s - t)\, Y(t)\, dt = F(s)$, which plays a dominant role in the theory of the Laplace transformation. M. A. Dengler, USA

1151. Panov, D. Yu., Handbook on the numerical solution of partial differential equations [Spravochnik po chislennomu resheniyu differentsial'nikh uravneniĭ v chastnikh proizvodnikh] 4th ed., Moscow-Leningrad, Gosud. Izdat. Tekh.-Teor. Lit., 1950, 183 pp.

This compact little book presents in brief form a quite complete introduction to the methods of solving partial differential equations by means of nets and associated difference equations. The introductory chapter shows how a two-dimensional region is covered by a net, usually rectangular, and how the differential equation (in this case, Laplace's equation) is replaced by a difference equation. The second chapter develops the essential features of the difference calculus, presenting formulas, diagrams, and tables of coefficients for Newton's, Stirling's, Bessel's, and Lagrange's ($n = 3$, $n = 4$) methods of interpolation, and for

Stirling's and Bessel's formulas for numerical differentiation. Difference formulas for partial derivatives are included. Chapter III deals with the choice of nets, the various difference formulas for Laplace's operator, solution of the finite linear system by iteration, accelerating convergence, formulas for corrections, and examples of the numerical solution of Dirichlet problems. Numerous figures and diagrams aid the explanations. In similar manner, chapter IV treats the biharmonic equation, V the heat equation, VI the wave and telegrapher's equations, and VII the quasilinear hyperbolic system. The methods are well illustrated by worked examples.

Courtesy of Mathematical Reviews W. E. Milne, USA

1152. Shumyagskiĭ, B. M., Tables for the solution of cubic equations by the method of bases [Tablitsí dlya resheniya kubicheskikh uravneniĭ metodom osnov], Moscow-Leningrad, Gosud. Izdat. Tekh.-Teor. Lit., 1950, 135 pp.

The cubic equation whose roots are tabulated is taken in the form: (1) $z^3 + Az = A$. The general cubic, once it is reduced to the usual trinomial $y^3 + py + q = 0$, becomes (1) when $-qz/p$ is submitted for y. Equation (1) has the roots $z_1 = -3$, $z_2 = 3/2$, $z_3 = 3/2$ when $A = -27/4$, and has three real roots for all A not exceeding this value, the roots tending to $-\infty$, 1, and $+\infty$, respectively, as $A \to -\infty$. For $A > -27/4$, the equation has, besides the real root z_1, the two complex roots $z_{2,3} = (-\frac{1}{2} \pm i\alpha)z_1$. For $A > -27/4$, the tables give z_1 and α; for $A < -27/4$, the tables give z_1 and z_2. (Of course, $z_3 = -z_1 - z_2$.) The tables are arranged in four parts with equal intervals given sometimes to the A's and sometimes to the z's, with a view to maintaining about 4 significant figures in the z's and α's by means of either direct or inverse linear interpolation.

Courtesy of Mathematical Reviews D. H. Lehmer, USA

1153. Cohen, H., The stability equation with periodic coefficients, *Quart. appl. Math.* **10,** 3, 266–270, Oct. 1952.

Author approximates a periodic solution, and so a division between stable and unstable solutions, for a particular second-order ordinary differential equation with "small" nonlinear part. He employs expansions in series of powers of the small parameter about a periodic solution of the linearized equation. Method is direct, simple in concept, and immediately applicable to an important class of differential equations. C. Ablow, USA

1154. Kober, H., Dictionary of conformal representations, New York, Dover Publ., Inc., 1952, xvi + 208 pp. $3.95.

This is a collection of formulas and properties of a large number of conformal representations. They are conveniently classified according to the type of function describing them, or, in some cases where more convenient, to the type of curve or region which they form in the mapping. No proofs are given, but the list of references is very thorough, so one can readily find a more complete explanation or detailed derivation. The handy table of contents and topological subject index makes the collection readily usable to anyone having a background in functions of a complex variable. There is also a very necessary list of notations and nomenclature for those a little rusty in their conformal representations. Also, some helpful examples are worked out to illustrate combinations of mappings. The book should prove useful for applied mathematicians, physicists, and engineers.

The contents are as follows: Part I. Linear and bilinear transformations; part II. Algebraic functions, including all real powers of the variable, the Joukowsky (airfoil) transformation and its generalization, and the plane with equally spaced slits; part III. The exponential, logarithmic, and related transformations; part IV. The Schwartz-Christoffel transformations (jets, barriers, Borda nozzles, etc.); part V. The elliptic functions and higher transcendentals (mapping of rectangles, triangles, etc.).

This is the dictionary that was originally published in five separate parts during 1944–1948 by the British Admiralty. However, this new single collection with an organized index far surpasses in usefulness the original set of mimeographed notes. I remember looking for hours trying to find the mapping from the *interior* of an ellipse to the *interior* of a circle, failing to find it, and spending more hours in working it out. With this new book, I looked in the index and had my answer in a few seconds. I recommend this book very highly. E. V. Laitone, USA

1155. Markushevich, A. I., Theory of analytic functions [Teoriya analiticheskikh funktsiĭ], Moscow-Leningrad, Gosud. Izdat. Tekh.-Teor. Lit., 1950, 703 pp.

The vast work is divided into 8 chapters. First, author explains with unusual exactness fundamental ideas, gives necessary definitions, and proceeds to considerations on derivatives and integrals of functions of a complex variable. Then he gives theory of Dirichlet's series, of residues and their application, and makes the reader familiar with fundamental principles of conformal representation and corresponding questions.

Significant is the sixth chapter dealing with harmonic and subharmonic functions and illustrating their role in hydrodynamics. It is followed by sections about integral transcendents, meromorphic and elliptic functions. The subject of the last chapter is the theory of Riemannian surfaces and related questions. An extensive literature index concludes the book.

Book is one of the greatest and most excellent works of this kind. It is a result of author's lectures at Moscow University, and every mathematician will enjoy reading it. Material is given with unusual carefulness, presentation is clear and vivid. In reviewer's opinion, the engineer also will find reliable information about various questions of his practice. The work can be highly recommended to mathematicians and all computing engineers.

V. Vodička, Czechoslovakia

1156. Trost, A., Measurement of thicknesses under 1 mm with beta rays (in German), *Stahl u. Eisen* **72,** 16, 941–943, July 1952.

The first part contains a general survey on the application of β, γ, and x rays for thickness measurements of metal plates and the obtained accuracy. The second part deals in detail with the possibilities of β rays for this purpose. According to thickness and material of the plates, radium or artificial radioactive elements are recommended. By suitable choice, the measuring accuracy becomes 1% with a time constant of 0.3 sec for plates of 0.002 up to 1-mm thickness. Data of several radioactive elements and two electric circuits are given.

Margot Herbeck, Germany

1157. Fritze, H. W., Measurement of thicknesses up to 10 mm with x rays and Geiger counter (in German), *Stahl u. Eisen* **72,** 16, 943–945, July 1952.

A hollow-anode tube with spherical ray propagation and fed by a controllable voltage is used for thickness measurements of 1–10 mm metal plates by means of absorption of x rays. Two rays are cut off from the radiation field; the one penetrates the test probe, the other a comparison plate. After penetration, the two radiation intensities are measured by Geiger counters, and their difference is registered. The variation of thickness with rolling temperature is considered by calculation. An improvement of measuring accuracy by stabilization of the voltage is a future objective of the author.

Margot Herbeck, Germany

1158. Kolb, W., Measurement of thicknesses from 10 to 100 mm with gamma rays and Geiger counter (in German), *Stahl u. Eisen* **72,** 16, p. 945, July 1952.

Author describes measurements of thickness of 10–100-mm metal plates by means of γ rays originating in radium, radioactive iridium, cobalt, or selenium, and by use of multiplex Geiger counters. Since the counter works in the proportional range, the errors caused by fluctuations of voltage and temperature are to be eliminated by a differential circuit.

Margot Herbeck, Germany

1159. Berthold, R., Measurement of the thickness of nonferromagnetic layers on nonferromagnetic support with beta rays and Geiger counter (in German), *Stahl u. Eisen* **72,** 16, 945–947, July 1952.

To investigate the thickness of chromium layers (max 0.1 mm) on aluminum base by means of β rays of natural and artificial radioactive substances, the x rays originating in the surface layer are measured by Geiger counters. The energy of the radiation source has to be increased with layer thickness in order to get an equal sensitivity for layers of different thickness. The error in measurement, about 10% in the most favorable case, decreases with increasing difference in the ordinal number of surface and base material. Margot Herbeck, Germany

1160. Gilard, P., Jr., Theoretical study of a thickness-measuring apparatus for window glass (in French), *Rev. univ. Min.* (9) **8,** 9, 365–369, Sept. 1952.

Mechanics (Dynamics, Statics, Kinematics)

(See also Revs. 1171, 1180, 1278, 1444, 1449)

1161. Hain, K., On the synthesis of slider link mechanisms (in German), *Ing.-Arch.* **20,** 3, 184–188, 1952.

Author considers four-bar mechanisms with one and with two slider links, the synthesis of which was given by Beyer in 1939, and to which he applies here his well-known "method of point reduction." Instead of a correspondence between angles there now is one between angle and distance. When, in the construction of the linkage, three or four points are collinear, we have a block linkage, a cross-slider crank, or an angle-slide mechanism, respectively. Generation of a given curve by means of a slider link mechanism. O. Bottema, Holland

1162. Marsicano, F. R., On the stability of the motion of a nonhomogeneous disk moving on a polished horizontal plane (in Spanish), *Cienc. y Técn.* **119,** 601, 9–15, July 1952.

Paper is of theoretical importance. Author assumes the disk to be plane with geometrical and mass center not coincident. Lagrange's equations are applied and solved. Stability conditions show that center of mass must remain in the highest position to perform stable movement.

Mathematical development is simple and correct. Reviewer believes that the particular solution is quite original. The concept is universally accepted. Engineers began to pay attention to it when rapid vehicles appeared; centrifugal forces imposed low center of mass, but instability was an opposite and unexpected consequence. Differential equations of movement gave the answer. J. E. Carrizo Rueda, Argentina

1163. Braams, C. M., On the influence of friction on the motion of a top, *Physica* **18,** 8/9, 503–514, Aug./Sept. 1952.

A simple calculation gives, to a first approximation, the influence of sliding friction on the motion of a top spinning on a horizontal plane. For a spherical body with axially symmetric mass distribution, two effects are found: (1) The center of gravity will be lifted if it lies eccentric in the sphere; (2) the axis with the greatest moment of inertia moves toward the vertical, if the principal moments are unequal.

The equilibrium condition for the combination of the two effects is derived. The rising of the tippe top is ascribed to sliding friction. An ordinary top, describing its common regular precession, will usually roll; rolling friction contributes to the rising of the top.

From author's summary by H. Bilharz, Germany

1164. Müller, W., Dynamics. I Dynamics of the single body. II Systems of rigid bodies [Dynamik. I Dynamik des Einzelkörpers. II Systeme von starren Körpern], Sammlung Göschen; Berlin, Walter de Gruyter & Co., 1952, Bd. 902, 903; 128 pp., 102 pp. DM 2.40.

These two booklets present a rather condensed synopsis of those topics in dynamics that are covered by some German texts on "Elementare Mechanik." For scope and level of presentation, they may be compared with the well-known text by Synge and Griffith. In general, the development of the subject matter follows the usual lines, but theorems and methods have been illustrated by typical examples worked out in detail and, wherever possible, selected with a view to their practical importance. In this manner, author has found it possible to include topics such as the piston-crankshaft assembly, the stability of the flyball governor, and the gyroscopic stabilization of a rolling ship.

For a brief review of dynamics, or as an auxiliary text for an intermediate course, the two small volumes can be highly recommended. Their usefulness, unfortunately, is impaired by the uncommonly large number of misprints. G. Kuerti, USA

1165. Haag, R., The canonical formalism in degenerated cases (in German), *ZAMM* **32,** 7, 197–202, July 1952.

Consider the equations of motion of a dynamical system in the variational form known as Hamilton's principle

$$\delta \int L(q_\alpha, \dot{q}_\alpha)dt = 0 \ (\alpha = 1, 2, \ldots, n) \qquad [1]$$

where L is the Lagrangian. If we form the Hamiltonian $H = -L + p_\alpha \dot{q}_\alpha$ where the variables $\dot{q}_\alpha$ are to be eliminated by means of the equations

$$p_\alpha = \partial L/\partial \dot{q}_\alpha \qquad [2]$$

the original equations [1] may be replaced by the equivalent system known as Hamiltonian or canonical equations of dynamics.

Author develops the "canonical formalism" for the case where the functional determinant $|\partial^2 L/\partial q_\alpha \partial \dot{q}_\alpha|$ of the system [2] vanishes. This leads to a system with superfluous variables p_α, q_α, i.e., relations $\Phi_i(p_\alpha, q_\alpha) = 0$ $(i = 1, 2, \ldots, r)$ hold, where $n - r$ is the rank of the system [2]. The reduction of the number of the independent variables and the meaning of a Poisson bracket relation $(A, B) = C$ between two functions A, B of p_α, q_α are discussed. It is shown that, in order that such a relation in p_α, q_α be meaningful, the functions A and B must satisfy the conditions $(A, \Phi_i) = (B, \Phi_i) = 0$.

E. Leimanis, Canada

1166. Maeda, K., Geometry of gears, *Sci. Rep. Res. Inst. Tôhoku Univ. Japan* (*A*) **3,** 3, 364–382, June 1951.

Author has formulated a plain but systematically beautiful theory on the meshing of gears by means of natural geometry. The form of a curve is thus determined by giving the curvature as a function of the length s of the arc. When, further, a fixed orthogonal frame Oxy is given, the location of a point is denoted

by $z = x + iy$, where $i^2 = -1$. A curve being given by a function $z(s)$, author introduces for another point ζ the complex coordinate Z by $\zeta = z + Z\,dz/ds$. Then Z is an invariant for any displacement of the curve and the point ζ as a whole.

Without going into technical details, author writes down and solves the differential equations to find the conditions for gearing and the tooth profiles. The moving rigid bodies do not necessarily need to be round cogwheels. They may have any form allowing smooth motion without shocks.

The first part contains the theory of spur gears (i.e., the plane rolling and sliding) and the theory of bevel gears (i.e., the spherical rolling and sliding). The third part shall deal with the meshing of the skew gears toothed with skew-ruled surfaces by utilizing Study's coordinate of a straight line.

Hilding Faxén, Sweden

1167. **Brandenberger, H., Calculation of friction loss and efficiency of planetary gears** (in German), *Schweiz. Bauztg.* **70,** 39, 559–562, Sept. 1952.

Author discusses speed, torque, and power relationships in planetary gear trains (general, no fixed gear) and displays these relationships graphically. He then shows the effect of tooth friction on torque and power. Examples clarify the calculation of power losses and efficiencies. Treatment should be of value to designers for its clarity and detail. A. S. Hall, USA

1168. **Williams, D., The mathematical theory of the snaking of two-wheeled trailers, with practical rules and devices for preventing snaking,** Instn. mech. Engrs. Auto. Div., 15 pp., 1952.

The system composed of "trailer and towing vehicle" (both with elastic tires) can show a "snaking" instability. A mathematical analysis basically similar to the Kantrowitz theory of shimmy [A. Kantrowitz, *NACA Rep.* 686, 1946] and making use of Routh's test functions is presented, which is stated to cover the facts at least qualitatively (model experiments are mentioned, but no account of experimental procedures and results is given).

The important parameters are (1) the distances of the trailer axle and trailer C.G. aft of the tow pin, (2) the trailer radius of gyration in yaw, (3) the frequency ratio of trailer and vehicle on their elastic tires. A simple linkage device is described, apt to prevent instability which can, even under adverse conditions, also be suppressed by damping, obtainable by aid of a slipping clutch in a torsionally stiff live axle for the two-wheeled trailer.

J. H. Greidanus, Holland

1169. **Lichtwitz, O., Mechanisms for intermittent motion,** *Engineering* **173, 174;** 4498, 4499, 4507, 4511, 4512, 4513, 4514; 452 455, 485–486, 740–743, 57–59, 91–93, 123–125, 156–158; Apr., June, July, Aug. 1952.

See AMR **5,** Rev. 3307.

Gyroscopics, Governors, Servos

(See also Revs. 1163, 1442)

1170. **Bückner, H., A formula for an integral occurring in the theory of linear servomechanisms and control-systems,** *Quart. appl. Math.* **10,** 3, 205–213, Oct. 1952.

Formula is for ${}_0\int^\infty y^2(t)dt$, where $y(t)$ is solution to homogeneous linear constant-real-coefficient differential equation of nth order whose associated polynomial has zeros with negative real parts. Only differential equation coefficients and initial values of $y(t)$ and its derivatives appear; zeros of polynomial need not be known. Formula is cumbersome but straightforward, and yields simple results for low-order equations. Derivation, mathematically rigorous, follows presentation of algorithms of reduction of a Hurwitz polynomial to one of lower degree. These also yield the Hurwitz stability criterion.

Practical importance is when $y(t)$ is error in a closed-loop control system, since integral-squared-error is an effective measure of transient behavior. Specific example given calculates coefficients which minimize integral. Reviewer believes paper may provide a useful new control-theory technique as a performance index not requiring solution for roots of equation.

A similar integral has been evaluated via Fourier transforms by Phillips [AMR **2,** Rev. 1359], and more simply by Kats [*Prikl. Mat. Mekh.* **16,** 3, 362–364, 1952]. M. S. Silberstein, USA

1171. **Loeb, J. M., A general linearizing process for nonlinear control systems,** "Automatic and manual control," New York, Academic Press, 275–280, 1952. $10.

A nonlinear control system is made linear by adding to the input quantity ϵ another quantity which is a periodic function of time ("sweep function"). Author shows (1) that the output is generally the sum of a constant term proportional to ϵ and a sine term, the amplitude of which is proportional to ϵ; (2) connection of this method to communication theory, sweep function acting as carrier wave; (3) limitation of maximum response speed by the sweep function; (4) application to servo systems, especially to instrument servomechanisms. W. Oppelt, Germany

Vibrations, Balancing

(See also Revs. 1196, 1208, 1352, 1425)

1172. **Pursey, H., Effect of variation in diameter on the torsional vibration of bars,** *Nature* **170,** 4325, p. 502, Sept. 1952.

On basis of a method described by P. M. Morse in his book "Vibration and sound," calculations for the frequency deviations in the bars are given. Morse has a chapter for a string of nonuniform mass and tension. The variation in the distribution of mass along the string disturbs the harmonic relation between the overtones. Pursey has a similar theory for calculation of the resonant frequencies in cylindrical bars with torsional vibration and a variation in the diameter of the bar along its axis, and frequencies for the "overtones" (measured and calculated) are tabulated for a bar of aluminum approximately 4 in. long by $^1/_2$-in. diam, the diameter being reduced on a length of the bar.

A. R. Holm, Denmark

1173. **Budiansky, B., and Kruszewski, E. T., Transverse vibrations of hollow thin-walled cylindrical beams,** *NACA TN* 2682, 29 pp., Apr. 1952.

From energy considerations, the integral differential equations and boundary conditions for the transverse vibration of a cylindrical beam are established. Cross section is assumed symmetric in direction of deflection and to be constant in space and time. Longitudinal and shear deformations of each circumvential element are considered so that effects of shear deformation and what is usually termed rotary inertia are considered. Solutions of equations are given for beams of uniform wall thickness and of arbitrary cross section for the boundary conditions of cantilever and free-free ends. Numerical examples for rectangular beams of various geometry are given. Secondary effects of shear and rotary inertia become large for higher modes, beams of small span, and for cross sections closer to square.

Paul A. Libby, USA

1174. **Johnson, D. C., Vibration of a rotating elastic body,** *Aircr. Engng.* **24,** 282, 234–236, Aug. 1952.

General equations are derived for the vibration of rotating

bodies. Effect of rotation is shown to alter natural frequencies, change mean position of vibration, and produce phase differences between different parts of body. Solutions are obtained for thin uniform shaft (with and without end rotor) and for thin uniform ring. Damping forces are excluded. R. N. Arnold, Scotland

1175. Aggarwal, R. T., Axially symmetric vibrations of a finite isotropic disk. I, *J. acoust. Soc. Amer.* **24,** 5, 463–467, Sept. 1952.

Some frequencies for the symmetrical normal nodes of a finite, isotropic disk are calculated by satisfying the boundary conditions exactly at the flat surfaces and approximately at the curved surface. It is found that two sets of frequencies occur for each vibration pattern. One set approaches the odd-order thickness compressional frequencies, whereas the other approaches the even-order thickness shear frequencies, as the radius of the disk increases indefinitely. As a test of the validity of the approximation, maximum residual stresses at the curved surface are compared with the compressional component of the stress at the center of the disk.

Reviewer thinks that, when mentioning other papers treating almost the same problem, author could have mentioned the following paper by G. Pickett: "Dynamic testing of pavements," *J. Amer. Concr. Inst.* **16,** 5, 474–489, Apr. 1945.

From author's summary by Sven T. A. Ödman, Sweden

1176. Rost, J., Determination of the generalized mass by the "impedance" method (in French), *Rech. aéro.* no. 28, 49–52, July-Aug. 1952.

Systematic procedure is proposed for obtaining the generalized mass associated with any normal mode of vibration of a linear structure, using data from well-known vibration-testing methods. Account is taken of presence of small amounts of viscous and dry friction, latter being represented approximately by first term of a Fourier-series development. Assuming sinusoidal excitation of nearly pure mode, all forces are referred to a selected reference station and all relative amplitudes of motion to another station. Generalized mass is computed through equality between work done by exciting forces and energy dissipated by friction. This calculation relies on a separate measurement of viscous damping coefficient from records of decaying motion, which appears to limit accuracy of results. Magnitude of dry friction forces can be estimated as corollary to generalized mass determination.

Two examples demonstrate usefulness of technique which seems basically sound, provided friction is sufficiently small and independent of amplitude. A more conclusive demonstration, involving more than one or two exciting forces, would be desirable. In this connection, Lewis and Wrisley [AMR **4,** Rev. 1460] describe and give examples of a practical method by which very pure normal modes are obtainable using eight or more shakers.

Holt Ashley, USA

1177. Morton, A. J., Tabular methods for critical speed calculations, *Engineering* **173,** 4505, 4506; 674–675, 704–707; May, June 1952.

Two closely related approximate numerical methods are presented for calculating the critical speeds of nonuniform shafts or rotors. The actual rotor is replaced by a modified, sectionalized rotor, and a power series is used to solve the governing equation. Final frequency equation is solved by trial and error.

Examples include the calculation of the fundamental frequency for (a) turbine blade; (b) Metropolitan-Vickers turbine rotor; and (c) marine turbine rotor with overhung disk. Accuracy of methods is checked against known exact solutions for lateral vibration of prismatical bars. Percentage of error (a function of number of sections selected) is small. Methods are adaptable to shafts with flexible bearings; gyroscopic effects; etc. In many respects the methods are similar to those of Holzer (for torsion) and Myklestad (for bending). E. W. Suppiger, USA

1178. Minorsky, N., On vibrating systems containing inertia parameters (in French), *C. R. Acad. Sci. Paris* **235,** 12, 604–605, Sept. 1952.

Author applies the stroboscopic method to the van der Pol equation for a circuit containing conductors whose resistance varies with the temperature. Conditions for stability are those previously obtained by K. F. Theodorchik, who treats the same problem by a graphical procedure. A more general problem, namely, the production of maintained oscillations in a circuit without triode tubes, is then studied. By the stroboscopic method, necessary conditions so that a stable oscillatory regime can exist are obtained. E. J. Scott, USA

1179. Gallagher, J., and Volterra, E., A mathematical analysis of the relaxation type of vehicle suspension, *J. appl. Mech.* **19,** 3, 389–396, Sept. 1952.

The "relaxation type" of vehicle suspension consists of a spring connected in parallel with a spring and a dashpot connected in series. Analysis presented here contains the responses of this system to transient disturbances and to steady-state oscillations, when the vehicle is moving over a road having a sinusoidal profile. Results are plotted. Authors state that the relaxation suspension presents considerable advantages in comparison with the standard type of suspension. They neglect, however, the effect of tire deflection. J. Rotta, Germany

1180. Crossley, F. R. E., The free oscillation of the centrifugal pendulum with wide angles, *J. appl. Mech.* **19,** 3, 315–319, Sept. 1952.

The usual nonlinear equations of motion are derived for a centrifugal pendulum. By means of a solution previously obtained by author, curves are plotted giving the period of the pendulum motion as a function of amplitude for various values of the moment of inertia ratio. From these curves, it is seen that the period is decreased by increase of the moment of inertia ratio; which fact was overlooked by previous investigators. The free motion of the carrier itself is finally found by means of some approximations and for reasonably large values of the moment of inertia of the carrier. N. O. Myklestad, USA

Wave Motion, Impact

(See also Revs. 1262, 1303, 1304, 1305, 1308)

1181. Yntema, R. T., An impulse-momentum method for calculating landing-gear impact conditions in unsymmetrical landings, *J. aero. Sci.* **19,** 11, 743–750, Nov. 1952.

Paper is an abbreviated version of *NACA TN* 2596 [AMR 5, Rev. 2336], omitting mathematical derivations and some refinements of the analysis. F. J. Plantema, Holland

1182. Flügge, W., Landing-gear impact, *NACA TN* 2743, 91 pp., Oct. 1952.

Paper deals with the impact forces acting on landing gears of an airplane. Linear differential equations for an idealized type of landing gear are developed and solutions are obtained. Special cases of negligible wheel mass and negligible damping are considered. An investigation is made for the idealized landing gear of taxiing impact resulting from an obstacle consisting of a step in the runway. Differential equations are developed for the oleo strut, including nonlinear elasticity of the air spring, velocity-

square damping, and the nonlinearity resulting from a metering pin. Numerical integration methods are used. The shape of the metering pin to give a desired load history for a particular case of impact conditions is discussed. Some general considerations are given to the airplane as a three-dimensional structure. A review of German literature on landing-gear impact is also included.

P. G. Jones, USA

1183. **Smiley, R. F., The application of planing characteristics to the calculation of the water-landing loads and motions of seaplanes of arbitrary constant cross section,** *NACA TN* 2814, 37 pp., Nov. 1952.

Purpose of paper is to calculate impact loads and motions from planing characteristics. As in previous papers on impact theory, the assumption is made that the instantaneous forces during a landing and in planing depend only on the components of motion normal to the keel. The differential equation of motion based on this assumption is presented and then integrated to obtain equations for the time histories of the draft, velocity, and hydrodynamic load during an impact. The validity of the resulting equations is then tested by comparisons of experimental and calculated impact loads and motions for water landings of a rectangular flat plate. Though not mentioned by author, the results have particular application to hydroskis, very much in the news as a means of landing airplanes on water.

W. C. Johnson, Jr., USA

1184. **Shapiro, G. S., Propagation of elasto-plastic waves in bars of variable cross section** (in Russian), *Prikl. Mat. Mekh.* **16,** 3, 335–340, May/June 1952.

Author considers semifinite bars and linear hardening. This problem can be associated with investigations by H. A. Rachmatulin and J. B. Luntz concerning cylindrical and spherical wave propagations. In the first of the three sections of this paper, author derives general relationships. The fundamental equation for this problem, excluding linear hardening, was previously published by author. Presently, author includes linear hardening and obtains differential equations of characteristics in dimensionless terms. Stress equations are obtained in a finite form for the forefront of the elastic wave and the boundary front which separates elastic and plastic waves. These stresses are independent of the mode of pressure variation at the bar's end. Within the region of plastic deformations, a solution may be obtained from the lattice of characteristics. In the second section of paper, a complete solution in a finite form for a conical bar is developed. In the concluding part are presented certain cases which are pertinent to bars with a constant cross section. It includes an investigation of a bar which is confined in an absolutely rigid shell, with an assumption that no friction exists between the bar and the shell. Author demonstrates that the basic solutions which are obtained for propagation of elastic nonlinear vibrations may be extended to include a case of finite deformations.

V. A. Valey, USA

Elasticity Theory

(See also Revs. 1189, 1238)

1185. **Slobodyanskiĭ, M. G., Evaluation of the error of an approximate solution in linear problems, reducible to variational problems, and their application to the determination of two-sided approximations in static problems of elasticity theory** (in Russian), *Prikl. Mat. Mekh.* **16,** 4, 449–464, July/Aug. 1952.

Author establishes upper and lower bounds to the solution of problems derivable from a variational principle. The method of approach draws heavily on the works of Friedrichs [*Math. Ann.* **109,** 1934] and also on S. G. Michlin [AMR **5,** Rev. 2248]. Starting with a pair of linear functional equations, $Au = f$, $Av = \psi$, where A is a symmetric positive definite operator, and u, v, f, ψ are elements in Hilbert space, the problem is to determine u and v.

The functional equations above are derivable from the functionals $F_\psi = (Av, v) - 2(v, \psi)$, $F_f = (Au, u) - 2(u, f)$ by a variational principle. A sequence of approximations u_n, v_n are determined in usual manner. Several formal manipulations using the properties of a Hilbert space lead to determination of bounds on the solution.

The method of solution is then applied to the determination of elastic displacements of a domain D, bounded by two surfaces S_1 and S_2. The displacements are determined after the Green function is determined. For this case, author shows that the methods of Trefftz and Ritz, which lead to lower and upper bounds, respectively, are special cases of his more general approach. A discussion of the convergence of the approximations is given.

Further applications are made to the bending of plates under various boundary conditions, and concrete examples are worked out, supplemented by numerical results.

Reviewer believes this paper to be a worthwhile contribution to the ever-growing stock of advanced methods for the solution of important problems in elasticity. J. J. Brandstatter, USA

1186. **Solyanik-Krassa, K. V., On the solution of the axisymmetrical problem of the theory of elasticity** (in Russian), *Doklady Akad. Nauk SSSR* (*N.S.*) **86,** 3, 481–484, Sept. 1952.

Author begins with Love's equations in cylindrical coordinates for a body of revolution symmetrically loaded. The problem can be solved by two stress functions, which are to be chosen so as to satisfy the boundary conditions and the conditions at the axis of the body. General equations are also given in curvilinear coordinates and are specified for the special case of elliptical coordinates. In this manner, one can obtain the concentration of stresses in a circular plate with elliptical hole in the axis.

Z. Bažant, Czechoslovakia

1187. **Shapiro, G. S., On the limit equilibrium of a granular wedge and the discontinuous solution of statics of granular media** (in Russian), *Prikl. Mat. Mekh.* **16,** 2, 253–254, Mar./Apr. 1952.

This very brief paper concerns a method of determining the state of stress for a wedge-shaped region. The method employed is essentially due to Prager [AMR **2,** Rev. 186]; i.e., the method of discontinuous solutions in plasticity. By way of illustration, the problem of a wedge subject to a normal load on the top surface is treated. Formulas, both graphical and analytical, are given in order to determine the stresses σ_x, σ_y, τ.

J. J. Brandstatter, USA

Experimental Stress Analysis

1188. **Ryan, J. J., The plate analogy as a means of stress analysis,** *Proc. Soc. exp. Stress Anal.* **10,** 1, 7–28, 1952.

Without or with constant body forces, the stress distribution in a homogeneous isotropic plate under plane stress (or strain) and the deflections of a plate loaded with lateral forces and moments at the edges are governed by the same bipotential equation. This fact has been used by H. Cranz to determine the stresses in notched plates by loading the plate in bending and measuring the radii of curvature optically. In this paper, the theory of the plate analogy is investigated, and the Cranz method applied to

cases where the results are known photoelastically. The first experimental difficulty is to apply the correct boundary values to the edges of the bent plate, which may be virtually impossible for complicated loading conditions. The curvatures are measured according to a method suggested by Einsporn, with which the astigmatic effect on a reflected, originally parallel beam of light, caused by the curvature of the reflecting surface, is used. In reviewer's opinion, a somewhat simpler arrangement could be obtained by using the "moiré effect," as suggested by Ligtenberg [AMR 5, Rev. 2623]. The scatter in the results is appreciable and the accuracy proved to be rather poor. As a result, the application of the plate analogy as a means of stress analysis, at least in this form, is not recommended.

R. G. Boiten, Holland

1189. Ikeda, K., Soap film technique for solving torsion problems, *Japan Sci. Rev.* **2, 2, 113–118, Aug. 1951.**

Author devises an improved optical apparatus of Salet type for experimental solution of Saint Venant torsion problem; i.e., for photographing directly contours of constant slope of (deflated) soap film. Apparatus is simple and would not be difficult to use by those so desirous. From several examples author claims errors of less than 3% and 5% for stress and torsional rigidity determination, respectively. In reviewer's opinion, since excellent simple numerical methods are available for solving Laplace and Poisson equations, interest in analogs for this torsion problem is now only academic. F. S. Shaw, USA

1190. Kufner, M., Photoelastic investigation of elastic plates (in German), *Schweiz. Bauztg.* **70, 38, 39; 545–549, 563–566; Sept. 1952.**

The stress distribution in plates, loaded perpendicularly to their plane, can be determined photoelastically by the aid of the frozen-stress method. As a model material, Dekorit is used, which is annealed at 115 C during 5.5 hr. Thereafter it is loaded at a temperature of 85 C for 2 hr and then slowly cooled down. To prevent the development of edge stresses, the material and the model are protected by a cover of aluminum foil during all the thermal treatments. The first example deals with a circular plate, supported at the edges and loaded at the boundary of an eccentric circular hole. In the second example, the stress distribution in circular plates with clamped edges, loaded by continuous pressure up to large deflections (ratio between center deflection and plate thickness varying from 0.465 up to 2.93), is compared with the theoretical solutions of Way and Federhofer. The results are in close agreement with each other.

R. G. Boiten, Holland

1191. Kuske, A., Photoelastic investigation of plates with the two-layer method (in German), *ZVDI* **94, 22, 745–747, Aug. 1952.**

There exist various methods to study the stress distribution in bent plates. A method is described by which two plates of different materials are cemented together, the optical sensitivity of the two materials being different. Suitable materials proved to be plexiglas and phenol-formaldehyde resins with Plexigum KP 8013 as a bonding agent. The difference in the optical sensitivity causes different retardations in the two halves of the bent plate, resulting in an optical pattern similar to that with normal two-dimensional models (plates loaded in their own plane), showing isoclinic and isochromatic lines. The possibilities of the method are outlined and some practical examples of plates of various shapes and clamped edges are presented.

R. G. Boiten, Holland

Rods, Beams, Shafts, Springs, Cables, etc.

(See also Revs. 1208, 1237, 1446, 1452)

1192. Wille, F., Bending of girders (in German), *Bautechnik* **29, 9, 249–253, Sept. 1952.**

Article gives a collection of formulas and examples for calculation of beams for various loading conditions and materials; the calculations are based on the use of influence lines. The given formulas, which are to appear as a book, may be used as a handbook and will enable the reader to shorten many static calculations. L. Föppl, Germany

1193. Da Silva Jr., J. F., Methods of analyzing continuous beams (in Portuguese), *Inst. Pesq. Tecnol., São Paulo, Bol.* no. 42, 128 pp., 1951.

This bulletin is an abstract of well-known methods with the emphasis on their principles and advantages, accompanied by thorough analysis and numerical examples. Beams with constant and variable moments of inertia are treated, and 33 tables are valuable for analysis of continuous beams with variable cross section, calculated for two different laws of variability and for various types of loading. Similar tables, however, for different variabilities have already been published by Walter Ruppel in paper no. 1598 [*Trans. Amer. Soc. civ. Engr.* **90,** June 1927]. The following methods are discussed: Clapeyron, Castigliano, Menabrea, Fontviolant, method of three-moments equations, of elastic rotations, of successive distribution of moments, of fixed points, of moment distribution by Hardy Cross, of five-moments equation, and others. Booklet has character of a textbook.

J. J. Polivka, USA

1194. Brush, D. O., Sidebottom, O. M., Smith, J. O., Plastic behavior of engineering materials. Part 1, Axial tension and bending interaction curves for members loaded inelastically, *Wright Air Develop. Center tech. Rep.* **52–89, part 1, 41 pp., Aug. 1952.**

Beam of arbitrary symmetric cross section, made of a linear strain-hardening material, is loaded in combined tension and bending. If fibers in cross section are inelastic to a certain depth, bending moment and axial force must satisfy a certain relationship. This relationship may be plotted as an interaction curve. If the deflection is known, the proper point on the curve may be determined.

Details for constructing interaction curve are given, and it is proved that, for sufficiently small moment, it is a straight line. Several methods of estimating deflections are given and compared. Experimental interaction curves were obtained for annealed rail steel and two aluminum alloys by eccentric axial loading. Results were found to agree closely with theoretical curves.

Results are valid only when axial load is tensile, since otherwise, buckling may occur. It is suggested that method may be extended to be of value in compressive case also. Two illustrative problems are solved in an appendix. P. G. Hodge, Jr., USA

1195. Goldberg, J. H., Torsion of I-type and H-type beams, *Proc. Amer. Soc. civ. Engrs.* **78, Separ. 145, 20 pp., Aug. 1952.**

Beginning with a review of pure torsion and torsion bending of I-type and H-type sections, the basic differential equation is obtained for the twisting of such sections. The stresses resulting from twist—namely, the simple torsional stresses and longitudinal and shearing stresses due to warping restraints—are discussed from the engineering viewpoint. Particular solutions of the differential equation are obtained for various warping conditions at the ends, and it is shown how these solutions are combined to formulate and

analyze various problems, including that of a framed floor panel. The concept of the warping angle is introduced in the belief that its easily visualized character leads to a simpler formulation of problems lying within the scope of this theory.

From author's summary by R. C. Knight, England

1196. **Jasper, N. H., A theoretical and experimental study of propeller-shaft failures,** *David W. Taylor Mod. Basin Rep.* 808, 65 pp., July 1952.

Tailshaft failures have received considerable attention in the past years. Paper presents a detailed study of vibrations and stresses in the propeller shaft of a tanker of the "Mission" type. The study is based on full-scale tests as well as on theoretical investigations. Special emphasis is placed on the effects of whirling flexural vibrations. One of the principal conclusions is that the shaft failure is due to reduction of endurance strength in consequence of fretting action and salt-water corrosion. Recommendations are given on how to prevent such fractures.

From author's summary by P. Kohn, Czechoslovakia

1197. **Waters, H., The effect of end restraint on beams and tie bars,** *Civ. Engng., Lond.* **47,** 555, 735–737, Sept. 1952.

Author considers the problem of transverse loading of a uniform beam pinned to rigid supports at each end. A transcendental equation for the axial tensile force is obtained. Two approximate solutions are introduced, one of which approaches the exact solutions for stiff beams, and the other for slender members (such as tie bars). Author also presents the corresponding approximate formulas for calculating the ratio of the actual maximum stress to that of an unrestrained beam. Conclusions regarding the effect of end restraint are: (1) For stiff beams, the deflection and maximum stress are little changed, but considerable horizontal loads are set up at the supports. (2) For long, slender members, the deflection and maximum stress are greatly reduced, and, again, relatively large forces are exerted at the supports.

T. H. H. Pian, USA

1198. **Heller, S. R., Reinforced circular holes in bending with shear,** *Soc. nav. Arch. mar. Engrs.*, 17 pp., Nov. 1952.

A family of specimens covering the usual structural practice, holes up to half the depth of the web, was tested. Reinforcement of twice the area of the hole was originally provided; successive machining operations reduced the amount of reinforcement in steps of half the hole area to zero reinforcement. SR-4 strain-gage observations at the hole, in the web, and on the flange of the I-beam were made, and the maximum stress in each region determined. The experimental results are summarized in a chart suitable for design purposes for I-beams of usual structural proportions.

From author's summary

Plates, Disks, Shells, Membranes

(See also Revs. 1190, 1191, 1205, 1206, 1226, 1232, 1414)

1199. **Fridman, M. M., Solution of the general problem of bending of a thin isotropic elastic plate supported along one edge** (in Russian), *Prikl. Mat. Mekh.* **16,** 4, 429–436, July/Aug. 1952.

L_0 is the outer, L_1, L_2, . . ., L_m inner edges of a thin isotropic elastic plate, supported by joints along L_0 and coupled also by joints to rigid disks along L_1, L_2, . . ., L_m. The load consists of a normal nonuniform pressure and of linear forces acting along the internal boundaries.

Mathematical formulation of the question shows its analogy with the plane problem of elasticity for the case where normal component of displacements and tangential component of external forces are given along the boundary. Sherman [title source, **7,** 6, 1943] gave a method of solving such problems of elasticity. Using the analogy mentioned above, author applied Sherman's method to his own problem.

The solution is elegant, from mathematical point of view. Of course, it presupposes good knowledge of the theory of functions, especially of Muskhelishvili's methods and of many advanced facts about integral equations of Fredholm's type.

V. Vodička, Czechoslovakia

1200. **Tâche, J., Some cases of stresses in circular rings** (in French), *Bull. tech. Vevey* **11, 12,** 1, 1: 32–40, 35–47; 1951, 1952.

Starting from the known solutions of the stresses and strains in rings produced by loads and moments distributed symmetrically on the circumference, additional complicated kinds of loading are treated. Among these are cases of technical importance, such as the ring-plate coupling and the ring spring.

E. Siebel, Germany

1201. **March, H. W., Behavior of a rectangular sandwich panel under a uniform lateral load and compressive edge loads,** *For. Prod. Lab. Rep., U. S. Dept. Agric.* no. 1834, 29 pp., 3 tables, 7 figs., Sept. 1952.

Report concerns behavior of simply supported sandwich panels under the combined action of a uniform lateral load and uniform edge loads. Formulas are derived from which deflection, bending moments, and reactions at the supports can be obtained. Assumptions used for sandwich are: (1) Faces are thin enough to be considered merely as membranes; (2) core furnishes shear rigidity but not flexural rigidity; (3) deflections are small; and (4) face and core materials are isotropic. Computations for maximum deflection, maximum moment, and maximum reaction are made for a square panel for three values of core rigidity, and for different combinations of edge loads and lateral load.

H. J. Plass, USA

1202. **Clark, J. W., and Moore, R. L., Torsion tests of aluminum-alloy stiffened circular cylinders,** *NACA TN* 2821, 38 pp., Nov. 1952.

Results are presented for the second series of torsion tests on aluminum-alloy stiffened circular cylinders. The significant observations from both series of tests are summarized and some comparisons are made with more recent theoretical work. In general, the mean observed shear-buckling strengths of the curved sheet panels agreed well with those indicated by the theoretical solution of Batdorf and Stein [see AMR **1,** Revs. 437, 809].

From authors' summary

1203. **Sonntag, G., Stress and pressure distribution in pipe clamp with initial clearance** (in German), *ZAMM* **32,** 10, 311–315, Oct. 1952.

For a pipe clamp (defined as a cut circular cylinder with bolt load and moment applied at the open ends) R. Sonntag ["Über ein neuzeitliches Festigkeitsproblem des Apparatebaues," *Chemie-Ing.-Technik*, 135–139, 1951] has shown that the radial clamping pressure cannot be uniform over the circumference where *no* initial clearance is provided between clamp and pipe.

In treating pipe clamp *with* initial radial clearance, author recognizes four distinct successive loading conditions with increasing bolt load: (1) Two diametrically opposite forces only, as in a nutcracker; (2) uniform radial pressure over major part of circumference, with radial force concentrations at points of separation of clamp from pipe; (3) ideal condition of uniform radial pressure over entire circumference; and (4) reversion to second condition with superposition of radial concentrated force at open

end. The singular ideal condition exists only for a sharply defined relation between clamping force and moment and radial clearance, and hence is not readily realized in practice.

Basic analysis assuming rigid pipe is supplemented by consideration of pipe compression due to clamping pressure.

A. R. C. Markl, USA

Buckling Problems

(See also Revs. 1201, 1222, 1223)

1204. Juillard, H., Buckling problems in straight rods, arcs and cylinders (in German), *Schweiz. Bauztg.* **70, 32, 33, 34**; 451–454, 468–472, 487–489; Aug. 1952.

Paper begins by presenting four varied methods for solving the problems of buckling of straight rods. The results are then discussed in detail in order to obtain a clear idea of the buckling phenomena. The method of successive approximations given is very interesting and could be used for evaluating the buckling of rods of nonuniform cross section.

Further, stability of rings and arcs stressed by external pressure is considered and related to pressure pipes of large diameter laid in rock tunnel and prestressed by concrete injections. As a practically realized example, the pressure conduit in Oberhasli, Switzerland, is cited, with internal pressure 68 atm, diam 2400–2600 mm, and thickness of the walls 10–20 mm. Though these conditions are not favorable, the conduit is serving without failure, due to application of the presented theory.

V. Kopřiva, Czechoslovakia

1205. Ashwell, D. G., A characteristic type of instability in the large deflexions of elastic plates. I. Curved rectangular plates bent about one axis. II. Flat square plates bent about all edges, *Proc. roy. Soc. Lond.* (*A*) **214,** 1116, 98–118, Aug. 1952.

Using von Kármán's finite deflection equations, author analyzes the problem of the buckling of a steel measuring tape: A plate having an initial curvature which is subjected to a bending moment which is perpendicular to the axis of curvature, and the analogous problem of a flat rectangular plate subjected to bending moments along its four edges. Although of little practical concern themselves, these problems are of interest since they provide rare exact solutions for the snap-action buckling which is typical of curved shells.

Experimental results are presented which corroborate the theoretical work. M. L. Williams, Jr., USA

1206. Wittrick, W. H., Correlation between some stability problems for orthotropic and isotropic plates under bi-axial and uni-axial direct stress, *Aero. Quart.* **4,** part 1, 83–92, Aug. 1952.

Paper considers buckling of orthotropic plate under compressive loading N_x and lateral compression N_y, with certain restrictive conditions on N_y. For the cases of sides simply supported and ends simply supported or clamped, it is found that the two nondimensional functions

$$k = 2 + \left(\frac{b^2}{\pi^2} N_x - 2D_{12}\right) \Big/ \left[D_1 D_2 \left(1 - \frac{b^2 N_y}{\pi^2 D_2}\right)\right]^{1/2};$$

$$\lambda = \frac{a}{b}\left[\frac{D_2}{D_1}\left(1 - \frac{b^2 N_y}{\pi^2 D_2}\right)\right]^{1/4}$$

bear the same relation to each other as in the case of the isotropic plate with $N_y = 0$ (i.e., $k = b^2 N_x/\pi^2 D$, $\lambda = a/b$). Thus the range of utility of the standard buckling curves is extended considerably.

For the cases of sides clamped, ends simply supported or clamped, and $N_y = 0$, a different definition of k follows the appropriate isotropic buckling curves to within $\frac{1}{2}\%$ in practical cases. K. H. Griffin, England

1207. Klitchieff, J. M., Several applications of series to problems of elastic stability (in French), *Bull. tech. Suisse Rom.* **78,** 21, 273–276, Oct. 1952.

Two kinds of elastic problems are treated. The first consists of determining the buckling load of a compressed beam with supports of arbitrary stiffness at equal distances. The principal question—with regard to technical applications—relates to the minimum value of support elasticity in order to make the minimum buckling load equal to that for rigid supports. By means of a suitable series, author obtains very simple equations. Secondly, author treats, in the same manner, the buckling problem of a plate stiffened by beams at equal distances. Author gives a simple formula by which the distances can be computed, so that the buckling load becomes equal to that for rigid beams.

H. Neuber, Germany

1208. Trösch, A., Stability problems in rotating rods and shafts (in German), *Ing.-Arch.* **20,** 4, 258–277, 1952.

In following up recent researches by H. Ziegler [AMR 5, Rev. 350], author treats different applications of the dynamic criterion of stability, indispensable in some of the cases discussed. In part I, the stability of a rod under simultaneous thrust and torque is investigated, assuming the four different Euler boundary conditions (b.c.). Under certain b.c., rod is found to be unstable for any torque, however small; under other b.c., it is found to be stable, independent of an additional small torque. Known results of Euler and Greenhill enter as special cases. Stabilizing influence of linear damping is taken account of separately. In part II, a rotating thin massless shaft carrying a disk is considered, assuming different combinations of b.c., torque, and transverse load. Critical speeds are investigated, damping and gyroscopic influences are taken account of separately. Among interesting results recorded may be mentioned that resonance is found for regular precession of disk in same but not in opposite sense as that of rotation of shaft. F. K. G. Odqvist, Sweden

1209. Barbré, R., Influence of elastic clamping and bracing on the stability of beams (in German), *Bauingenieur* **27,** 7, 268–271, July 1952.

Essentially a condensed translation of a paper by A. R. Flint [AMR **5,** Rev. 1045]. S. H. Crandall, USA

1210. Getz, J. R., Effective flange width (in Norwegian), *Tekn. Ukeblad, Oslo, Tekn. Skr.* no. 3 N, 30 pp., 1951.

Paper is report no. 4 from the Norwegian research institute for shipbuilding. Theoretical investigations are referred to and brought forward, leading to practical conclusions over effective flange width to be used in calculating maximum stress and deflections for (1) beams with symmetrical nonbuckling flanges, the reduction of effective flange being caused by shearing strain; (2) beams with unsymmetrical nonbuckling flanges, where lateral bending takes place; (3) beams where the efficiency of flange is reduced on account of initial curvature or buckling. The curvature gives secondary bending stresses in flanges, and the possibility of yielding or fatigue failure is to be considered. In calculating buckling strength of plate stiffeners, secondary buckling of plate generally reduces effective flange width to about 50% of width used in stress calculations. S. E. Kindem, Norway

1211. Duncan, W. J., Multiply-loaded and continuously-loaded struts, *Engineering* **174,** 4515, 4516; 180–182, 202–203; Aug. 1952.

Author gives an exact treatment of some multiply loaded cantilever and pin-jointed struts, and obtains the critical load which is, in general, derived from the solution of a transcendental

equation. The case of continuously applied loads can be treated approximately, replacing the total loading on a segment of a strut by its resultant acting at the mean point of the loads. The value of the critical loading obtained approximately, using theorems based on the influence of constraints and knowledge of critical loads for each individual load point on isolation, is an underestimate of the true one and is on the safe side. The energy method, though it gives an overestimate of the critical load, is widely applicable, for results to a desired degree of accuracy can be obtained by minimizing the loading obtained from a constrained mode of deflection containing one or more variable parameters.

From author's summary by D. N. Mitra, India

Joints and Joining Methods

(See also Rev. 1269)

1212. **Puzak, P. P., and Pellini, W. S., Embrittlement of high-strength ferritic welds,** *Welding J.* **31,** 11, 521s–526s, Nov. 1952.

The effect of stress-relieving heat treatments of low-hydrogen, high-strength, ferritic welds of the Mn-Mo (Mil. E986-Ships Grade 230) and Ni-Mo-V (Grade 260) types were investigated to determine changes in properties which would be expected to affect the performance of weldments. It was established that the Mn-Mo type is essentially unaffected by stress-relief heat treatments. The Ni-Mo-V type exhibits a pronounced loss in notch toughness, which is ascribed to the precipitation of vanadium carbides, similar to age-hardening reactions. "Over-aging" resulting from prolonged holding at stress-relieving temperatures results in complete recovery of notch toughness. However, the strength properties are decreased considerably below the level of the as-deposited weld metal. It is concluded that the subject Ni-Mo-V welds are not suitable for stress-relieving heat treatment.

From authors' summary

1213. **Wentworth, R. P., and Campbell, H. C., Temper-brittleness in low-alloy steel weld metal,** *Welding J.* **31,** 11, 505s–514s, Nov. 1952.

Slow notch-bend tests revealed embrittlement resulting from postweld heating of 100,000 psi and 120,000 psi grades of Ni-Mo-V weld metal. Embrittlement was less serious in the lower strength grade. Temperature range of embrittlement was 1050 to 1150 F for the 100,000-psi grade, and 950 to 1250 F for the 120,000-psi grade. Long tempering times (over 10 hr) at 1200 F improved the ductility, and considerably shorter times (2 to 4 hr) at 1250 and 1300 F completely restored the ductility of the 120,000-psi grade. Authors also found that if the weld metal was initially rendered ductile by heating above the embrittling temperature range, the ductility could be retained despite subsequent heating in the range of embrittlement (950 to 1150 F). A 1650-F austenitizing heat treatment also appeared to be beneficial for 120,000-psi Ni-Mo-V weld metal as it narrowed the temperature range of embrittlement. Two Mn-Mo grades (low and medium carbon) of weld metal and type 2 Cr-$^1/_2$ Mo weld metal showed no tendency for embrittlement resulting from post-weld heating in the temperature range which caused embrittlement of Ni-Mo-V weld metal. Authors describe embrittlement of Ni-Mo-V weld metal as a temper-brittleness phenomenon; however, Puzak and Pellini (see preceding review) concluded from a similar study that the mechanism of embrittlement of Ni-Mo-V weld metal in the stress-relieving temperature range is due to a precipitation reaction typical of age-hardening systems. They point out that this embrittlement is different from the relatively slower and isothermally nonrecoverable embrittlement classed as temper brittleness.

F. J. Winsor, USA

1214. **Browning, J. A., and Thorpe, M. L., Basic flame studies and their relationship to welding equipment,** *Welding J.* **31,** 10, 465s–468s, Oct. 1952.

Paper represents study of factors affecting stability of propane flames and the relationship of these factors to welding and heating equipment.

From authors' summary

Structures

(See also Revs. 1181, 1182, 1192, 1455)

1215. **Da Silva Jr., J. F., Tables for the calculation of structures by the method of energy of deformation** (in Portuguese), *Inst. Pesq. Tecnol. São Paulo Publ.* no. 451, 50 pp., 1952.

Tables to solve the expression $\int M\bar{M}ds$ for straight beams with arbitrarily varying moment of inertia J. The variation of J is considered with the coincidence in twelve sections of the approximated function adopted for it (method of Prof. van Langendonck).

In reviewer's opinion, these tables permit a closer approximation to the variation of J than other known tables. The fact of adopting a variation of J without establishing the shape of the section, makes the tables applicable independently of this shape, as happens with those published in Kurt Beyer's well-known book, which author omits mentioning when he establishes the advantage of his work.

The possibility of a more accurate approximation to the variation of J must be useful to cover the region in which Beyer's tables are not very precise, i.e., for long haunches with other than rectangular sections. This possibility justifies the slightly greater amount of material work that their application demands.

The combinations of diagrams M and $\bar{M}$, including cases corresponding to partial loading, have been selected with very good practical criteria.

The observation could be made that the title of the publication is not in good agreement with its real object. Doubtless a work of practical value, especially as a complement to known tables for the same purpose.

A. J. Bignoli, Argentina

1216. **Pell, P. S., Thompson, N. E., and Coates, R. C., Structural analysis by models,** *Civ. Engng., Lond.* **47,** 553, 554; 559–561, 666–667; July, Aug. 1952.

Authors present a brief description of the analysis of indeterminate structures by the use of models, and include examples in which experimentally determined quantities are compared with calculated values. The techniques followed and the models and instruments used, including the Ruge-Schmidt moment indicator, are described, and references are given to more extended discussions. Some acquaintance with the subject is assumed.

R. J. Roark, USA

1217. **Neal, B. G., and Symonds, P. S., Plastic collapse loads for plane frames,** *Engineer, Lond.* **194,** 5041, 5042; 315–319, 363–364; Sept. 1952.

See also AMR **5,** Rev. 2598. Authors present rapid method for collapse analysis of rigidly jointed frames of ductile material (mild steel). It is shown that, for any frame, the total number of independent equilibrium equations is equal to the same number of partial collapse mechanisms. Since the solution is a linear combination of the equilibrium equations, it can also be derived as a linear combination of the partial collapse mechanisms. After discussion of principles in relation to a single-bay rectangular frame, authors give two examples of practical design; (1) a single-bay pitched-roof portal frame, and (2) a three-bay pitched-roof portal frame. In both cases, the correct solution is arrived at very quickly and is subsequently checked by construction of

bending moment diagrams. At any stage in the calculations, the combination of partial mechanisms is shown to lead to fully plastic moments that are too small. The proposed method may thus be tabulated as follows:

(1) Determine the correct number of independent mechanisms by calculating the number of independent equations of equilibrium. (2) Calculate the required values of the fully plastic moments of the members by virtual work for these independent mechanisms. (3) Investigate combinations of these mechanisms so as to maximize the required fully plastic moments. (4) Check the solution by constructing a bending-moment diagram.

Jacques Heyman, England

1218. Nicolsky, V. A., Remarks on the calculation of large bridges with multiple beams joined by stiffening girders. Author's reply by Mr. Guyon (in French), *Ann. Ponts Chauss.* **122,** 5, 613–629, Sept./Oct. 1952.

Author refers to a paper by Guyon bearing the same title [title source, 553–612, 1946] and observes (1) for the small values of the flexibility parameter θ, there is an error in the published values of the distribution coefficient K; (2) it would have been simpler to analyze the problem by means of simple series instead of the double series used by Guyon; (3) the width $2b$ of the fictitious homogeneous bridge used in the calculations differs from the width of the actual bridge; this point is not emphasized in Guyon's paper, and the confusion may give rise to important errors in the values of the moments in the cross beams.

In his reply, Guyon recognizes that (1) the errors indicated by Nicolsky actually exist, but observes that they are of the order of 1%, thus of no practical importance; (2) concerning the second criticism, he agrees with Nicolsky but indicates that, since the publication of his paper, this reviewer has already completely solved the problem by means of simple series [see Ch. Massonnet, AMR **4,** Rev. 2449]; (3) referring to the third point, Guyon thinks that it was clear enough in his paper to render any explanation unnecessary. Ch. Massonnet, Belgium

1219. Marguerre, K., On stresses in plate bridges (in German), *Stahlbau* **21,** 8, 129–132, Aug. 1952.

A new tendency in reinforced-concrete bridge construction is to let the concrete floor contribute to the resistance of the bridge, as a part of the upper chord of the main girders. As long as this concrete plate is not too thick, it may be considered as a purely compressed member, and the stresses therein are given by the usual plate-girder theory. But, if the concrete upper chord is very important, its own bending rigidity cannot be neglected; in this case, it works simultaneously as a plate and as a slice. Paper's goal is to establish the formulas giving the slice and plate stresses in the floor.

The loading investigated is a line load acting only on the main girders and distributed sinusoidally along them; this is the fundamental term of the development in Fourier series of any distributed line load. The calculations are completely worked out, so that the relatively simple results of the study can be directly applied. A numerical example is given.

Ch. Massonnet, Belgium

1220. Crosthwaite, C. D., Shear deflections in latticed structures, *Publ. int. Assn. Bridge struct. Engng.* **12,** 91–107, 1952.

It is known that the additional deflection of ordinary beams and plate girders, due to the influence of shear forces, depends on the depth/span ratio and may be neglected when this ratio is small. In the design of suspension bridges with plate-stiffening girders, this effect may, therefore, be neglected in most cases. Article deals mainly with the mathematical analysis of lattice-stiffened suspension bridges, where the shear effect may be worth taking into account. Author develops a procedure by means of which this may be done. The basic equation is that due to Melan's deflection theory, and the correction term due to shear effect is developed. The solution to the obtained equation is given by sine series. A worked-out example shows the effect of shear to give a reduction in bending moment and shear forces amounting to 6 and 8%, respectively. Finally, the same method is used to find the reduction of the buckling load of a laced strut as compared to struts of solid box section. The result is in agreement with formulas given by S. Timoshenko, "Theory of elastic stability" [McGraw-Hill, 1936]. Reviewer ventures to assume that the mathematical treatment of the problem might be improved if the differential equation is solved by what the author calls "any of the orthodox methods." The correction may then be expressed by one single term in the solution, and a discussion showing under what conditions the effect must be taken into account may be given. The necessity of taking 15 terms of the sine series into account is then avoided. It should be stressed that a similar procedure may easily be applied also in the case where Rode's equation is used as a basis [R. Gran Olsson, AMR **3,** Rev. 883]. Leif N. Persen, Norway

1221. Vincent, G. S., Mathematical prediction of suspension bridge behavior in wind from dynamic section model tests, *Publ. int. Assn. Bridge Struct. Engng.* **12,** 303–321, 1952.

Wind-tunnel tests on three-dimensional models of suspension bridges show sufficient correlation with the behavior of the actual bridges to indicate that the scale effect is small. Static wind-tunnel tests on models show that the effect of Reynolds number on drag, lift, and moment is negligible. When the logarithmic decrement for atmospheric damping in model tests in still air is plotted against amplitude of oscillation, the resulting curves reveal the action of forces whose strength varies as the square of the velocity with only a small component of viscous damping, indicating that the phenomenon follows Froude's law. These facts make it possible to use aerodynamic section-model tests to predict the behavior of the bridge in the wind.

When a section model (properly scaled as to form, mass, and mass distribution) is supported on springs designed to reproduce to scale the vertical, torsional, and coupled movements of the prototype and is exposed in a wind stream, the flow will be similar and the wind forces will be proportional to those associated with the prototype under corresponding conditions. The continuous record of the motion of the model will reveal the integrated work performed on it by the wind forces, and will indicate the rate per cycle at which the wind transfers energy to the oscillating system. This rate, which varies with the amplitude, will be the same on the prototype as on the model, the latter representing the conditions over a unit length of the prototype oscillating at a discrete amplitude. The energy transfer per cycle on the prototype can be calculated by integration over the length of the structure using the previously computed frequency and wave form of the mode under investigation. The steady-state amplitude in the given wind stream will be that at which the total energy input per cycle just equals that absorbed by the structural damping. The latter, for the prototype, must be known or assumed.

The structural damping of the model mechanism is obtained from tests with equivalent streamlined weights substituted for the section model. When this is subtracted from the damping of the model assembly in still air or a wind stream, the atmospheric damping for that condition is obtained. The tests are extended to sufficient amplitude to include the ranges of positive and negative atmospheric damping. The integration for the proto-

type is facilitated by expressing the logarithmic decrement as a power series in the amplitude. The curves vary much in form for different velocities.

From author's summary by F. L. Castleman, Jr., USA

1222. **Benjamin, R. J., Analysis of oval rings by Fourier series,** *J. aero. Sci.* **19,** 9, 585–592, 608, Sept. 1952.

Paper contains a new advantageous method for stress analysis of oval rings. The shape of the ring is represented by a Fourier series by use of a dimensionless parameter proportional to the arc of the ring. Computation of integrals along the curve of the ring, when using any strain-energy method for determining statically indeterminate forces and moments, is then very simple and requires no extensive mathematical background. Method is applicable to rings of any shape; however, rings having at least one axis of symmetry and symmetrically loaded, are more suitable for simplicity of the solution. Applicability of this method for fuselage ring design is apparent. Accuracy is high, as is seen by comparison with results obtained from precise solutions of elliptical rings; even a few terms of the Fourier series give good approximation. V. Kopřiva, Czechoslovakia

1223. **Shanley, F. R., Weight-strength analysis of aircraft structures,** New York, McGraw-Hill Book Co., Inc., 1952, xi + 304 pp. $8.50.

Book is a collection of stimulating papers dealing with subjects somewhat more varied than indicated by title. Principal theme is the derivation of expressions with which structural weight of aircraft may be calculated as two parts—the minimum or optimum weight necessary to do the required job, and excess or "nonoptimum" introduced by practical and other design considerations. This may prove a fruitful new approach for the weight engineer for prediction purposes and for identifying and controlling sources of weight penalties. Perhaps of greater interest to structural engineers in general are the methods of optimum design, by means of which the efficiency of various materials and various design configurations may be evaluated over entire range of application. Designer is thus provided with a tool to compare different arrangements for specific duty, select that of minimum weight, or be appraised of the penalty incurred through use of less efficient arrangement.

Already widely recognized papers on stress-strain-time properties of materials and tangent-modulus column theory are also included. The former is of increasing significance for structural design at elevated temperatures. Both provide highly practical interpretations of important subjects which the practicing engineer generally finds obscure. Other topics include creep-buckling of columns and the design of rings for stiffened shells to avoid general instability.

Some problems and an index are included, but reader should not expect a polished textbook. Value of the papers lies in high practical significance and different point of view, of interest both in and out of the aircraft field. P. E. Sandorff, USA

1224. **Drake, D. W., Friction surfaces for spin-up simulation in landing-gear drop tests,** *Trans. ASME* **74,** 7, 1269–1279, Oct. 1952.

Current procedures for drop testing of landing gears entail the simulation of wheel spin-up. The use of a fixed reaction surface in conjunction with spinning wheels in the drop tower introduces friction conditions between the tire and reaction surface that do not permit direct use of airport surfaces such as concrete. For this reason, the "coefficients of friction" of a number of reaction surfaces have been evaluated and their value for spin-up simulation is discussed.

From author's summary by T. H. Lin, USA

1225. **Franciosi, V., On the limit design of monodimensional structures in elastoplastic state** (in Italian), *G. Gen. civ.* **90,** 7/8, 387–400, July/Aug. 1952.

First part of paper surveys mechanical behavior of elastic-plastic structures [following Prager and Symonds, AMR **4,** Rev. 1558] and methods of limit analysis [following Greenberg and Prager, AMR **3,** Rev. 2273]. Second part discusses reduction of limit moments by axial forces. Iterative method of limit analysis is suggested, using axial forces obtained in one step to compute reduced limit moments for next step. Influence of axial forces on limit loads is small for structural frames of conventional design but significant for trusses with rigid joints.

W. Prager, USA

1226. **Baker, A. L. L., Ultimate strength theory for short reinforced concrete cylindrical shell roofs,** *Mag. Concr. Res.* no. 10, 3–8, July 1952.

The neutral axis of the whole cross section prior to failure (longitudinal *beam* bending) can be placed between two limiting positions, one giving ultimate compression stress in concrete at the crown, the other giving yield tension in steel at the edges. Longitudinal compression stress in concrete prior to failure is assumed to be uniform.

For each assumed position of the neutral axis and given distribution of load, the distribution of difference of membrane shear across a transverse strip is derived, and thus transverse bending moments and consequent radial deflection of the strip can be determined. This method was proposed earlier by the author [see AMR **4,** Rev. 3533]. When short cylindrical shells are considered, longitudinal *slab* bending may no longer be neglected.

In an ideal net of transverse and longitudinal strips, r_i should be at knot i, the ratio of load supported by the shell acting as a hollow beam subject to transverse bending, and $1 - r_i$, the one supported by slab bending of the longitudinal strip; by equating the radial deflection of the two strips in i, n simultaneous equations can be written.

A solution by successive approximations is proposed, assuming a first set of r values, graphically determined between maximum and minimum possible deflections at each point. Author hopes to check the results of this theory in the near future.

Reviewer believes that in fig. (6a) distance g_0 ought to be measured from CG to the left end of the ideal beam.

D. Gentiloni-Silverj, Italy

1227. **Völter, O., Critical considerations of the significance of the hook in reinforced-concrete structures** (in German), *Beton u. Stahlbetonbau* **47,** 7, 163–169, July 1952.

Author discusses the material presented in a paper by Dr. R. Bauer ("The hook in reinforced-concrete structures"), and raises an emphatic protest against a statement made therein concerning the significance of reinforcing hooks. He strongly opposes the conclusion reached by Dr. Bauer, that the conventional bond in reinforced-concrete structures is not reliable at all and should be considered only as supplying an additional factor of safety whereas the end anchorage in form of a hook should take its place in design. Author proves, by the theory of elasticity, that in case of a design based on the end anchorage, the elongation of steel would be much greater than in a case of conventional design based on bond which would produce excessive cracking and deflection, although the ultimate strength in both cases would remain nearly the same. Author is of the opinion that the design could be improved if more consideration were given to increasing the bond than to work on the improvement of hooks. Reviewer believes that author is correct in stating that the importance of the hook is greatly overdone by Dr. Bauer. As far as

reviewer knows, Dr. Bauer seems to stand alone in Germany with his belief that the hook is a panacea for all the ills of designers of reinforced concrete. There is in Germany a small book written by Dr. R. Bauer under the same title, published in 1949 by Ernst and Sohn, Berlin. J. B. Gabrys, USA

1228. Rudelstorfer, K., Most favorable transition lengths for highway superelevation (in German), *Öst. Bauzeitschr.* **7,** 4, 64–69, Apr. 1952.

Theoretical formulas are derived for determining transition lengths for superelevation of highway curves. Variables include weight of vehicle, velocity, radius of curve, and final superelevation. Derivation is based on centrifugal force.

Reviewer believes such procedure is more rational than current United States practice which relies on judgment and experience. Intangibles such as variable weather conditions, riding comfort, and allowance for a variety of vehicles are not and cannot be considered in formulas. M. W. Jackson, USA

1229. Klebowski, Z., Strength computation of vessels subjected to pressure (in Polish), Warsaw, Państw. Zakł. Wyd. Szkoln., 1951, 284 pp.

The first part of the book treats basic problems, with chapters on the plane stress; membrane stresses, shells whose meridians are bent, application of the theory of beams on an elastic foundation; vessel bottoms (with the use of the theory of circular plate); theory of curved rods, mechanical properties of materials used in vessel production. The second part deals with industrial applications, such as the computation of cylindrical vessels according to the state regulation; plane, convex, and saucerlike bottoms; flanges joint with the walls of axially symmetrical vessels loaded at the convex side (elastic instability phenomena); thick-walled vessels; vertical and horizontal containers axially symmetrical and nonsymmetrical; special structures. In the third part, applications of Love-Meissner's theory of elastic shells are given. There are many tables, graphs, and numerical examples which make this fundamental and clearly written book useful for specialists. New material of practical value can also be found in several sections; e.g., special case of bending of an annular plate; thin-walled circular cylinder supported along its two generators.
J. Nowiński, Poland

1230. Mintskovskiĭ, M. Sh., Bearing capacity of a wedge-shaped foundation loaded centrally (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **85,** 2, 281–284, July 1952.

Mathematical solution is given for the bearing capacity of a wedge-shaped strip footing in clay soil. Footing is triangular in vertical section with apex down, i.e., cutting into soil. It is indicated that such footings are used in areas subject to mining subsidence. Soil is characterized by coefficients of internal friction and of cohesion, i.e., general case of clay soil. Resulting equation for bearing capacity contains a transcendental expression which can be solved numerically. It is shown that if the slope angle of the wedge is made zero, the solution by Gorbunov-Possadok for the bearing capacity of a usual strip footing with horizontal base is obtained as a special case. Likewise, if the internal friction is made zero, Prandtl's solution of the pressure of a rigid strip into a plastic semi-infinite body is obtained as a further special case.
G. Winter, USA

1231. Rogers, P., Foundation for a large turbogenerator, *J. Amer. Concr. Inst.* **23,** 3, 213–222, Nov. 1951.

A practical method is presented for the structural design of large turbogenerator supports of reinforced concrete. The loads and forces acting on the support are enumerated, their origin is explained, and their values are appraised. Computations for one cross bent are presented in detail, and the advantages of embedded steel girders to resist horizontal forces are emphasized.

The method is applicable to the design of foundations for units of 20,000 kw or larger. The general layout and loading arrangement of all makes are similar, only the values of loading and dimensions differ. From author's summary

1232. Müller, W., On the theory of rectangular foundation plates and mushroom roofs (in German), *Ing.-Arch.* **20,** 4, 278–290, 1952.

Paper starts with the known method of double series for investigating rectangular foundation plates. It is assumed that the plate is elastically supported and that the reaction of this support, caused by load, is proportional to the deflection $w(x, y)$ of the plate. The principle of the new method is to reduce the double series to single series with aid of a formula indicated by A. Kneser. Author gives some examples of this method. In the present paper, he treats only deformations w of the plates; in a future paper, he will indicate the way to calculate the bending and torsion moments. L. Föppl, Germany

1233. Wood, R. H., and Goodwin, E., "Degree of fixity" methods for certain sway problems, *Struct. Engr.* **30,** 7, 153–162, July 1952.

Paper represents another addition to the growing list of publications attempting to reduce the computational labor in solving structural problems of a highly redundant nature. In this case, the familiar "degree of fixity" methods are modified through the inclusion of equally familiar "no shear" moment-distribution techniques to lead to a "direct" solution of wind-bracing problems of rigid frames. Actually, this approach represents a step-by-step inversion of the stiffness matrix, from which the translatory terms have been removed by means of the shear equations of equilibrium. E. F. Masur, USA

1234. Petroni, V., Break experiments with reinforced concrete and steel masts (in German), *Elektr. Masch.* **68,** 20, 481–493, Oct. 1951.

The stresses, deflections, and root moments arising in steel and concrete masts under a side load at the tip are calculated in detail by means of five different methods of calculation, due to Bürklin, Sulzberger, Ullmann, Dörr, and the author. Tests run on large-scale specimens are also described. The calculated results are compared, and their accuracy is discussed in view of the experimental data. Bruno A. Boley, USA

1235. Barta, J., Torsional stress analysis of lattice transmission line towers of rectangular cross section (in German), *Acta Techn. Hung.* **4,** 1/4, 265–272, 1952.

Paper concerns evaluation of stresses in horizontal and diagonal bars of a rectangular lattice tower, subjected to pure torsion. The theory presented is an improvement of an older one by Poczy [*Elektrotechnika, Hungary,* **43,** p. 317, 1950]. The basic hypotheses are: (1) All bars are hinged at their ends; (2) there are no bracing bars in the planes perpendicular to the axis of the tower; (3) the sections of the vertical members are very large, so that their deformation during torsion is considered negligible.

The stresses are obtained by means of least-work theorem. Explicit formulas and a numerical example are given. Finally, author questions whether it can be recommended that the standard specification formulas be replaced by the new ones. He concludes that a supplementary study is needed, which should take as a basis the detailed analysis published in the literature [e.g., *Stahlbau,* 1932, 1933, 1936, 1940, etc.] as well as experimental results on actual towers. Ch. Massonnet, Belgium

1236. **Vlachlis, D., Model tests on a thin prestressed barrel roof,** *Mag. Concr. Res.* no. 10, 9–16, July 1952.

The model was 12 m long and 4 m wide, supported on columns at the four corners. The roof was an elliptical barrel shell, 3-cm constant thickness and stiffened by 10 × 14-cm longitudinal edge beams, prestressed by the Freyssinet method. The paper discusses the distribution of stresses in the shell caused by uniform loading and effects of the prestress. The model was loaded with sandbags, but the only test data given are the load and deflection at which cracking first appeared in the prestressed longitudinal beams. For this load, a 2.07 safety factor was calculated.

I. A. Benjamin, USA

1237. **Uhlmann, H. L. B., The theory of girder walls with special reference to reinforced concrete design,** *Struct. Engr.* **30,** 8, 172–181, Aug. 1952.

A very useful article for designers of reinforced-concrete structures, paper sets out main features of design methods for deep beams ("girder walls") based on published work and research work done by author.

Stress patterns are determined by treating problem as two-dimensional. Solutions are obtained by successive approximation. Tension regions thus located are reinforced with steel in design of the following: Simply supported girder walls, girder walls continuous over a large number of supports, end span of a continuous girder wall, and girder wall with openings.

Ai-Ting Yu, USA

1238. **Sechler, E. E., Elasticity in engineering,** New York, John Wiley & Sons, Inc., 1952, ix + 419 pp. $8.50.

Book is divided into three main parts. First part has seven chapters on basic principles and equations in Cartesian, cylindrical, and spherical coordinates, necessary for solution of elastic problems. In this part are discussions on usual topics such as uniform and nonuniform stress and strain conditions; stress-strain relations; and elastic energy methods. In dealing with stress-strain relations for alloys like aluminum, which do not exhibit a well-defined yield point, author has introduced the term "defined yield stress," which may confuse the reader. The point called the defined yield stress is, in reality, the 0.2% proof stress. The latter aspect should have been more clearly mentioned, and the significance of the 0.1% proof stress and the ultimate tensile stress brought out. Reviewer would also have liked to see a chapter on the nondimensional stress-strain curves, or at least some discussion on the topic, which unfortunately is entirely omitted.

Second part of the text, containing five chapters, deals with engineering problems of stable structures, i.e., problems in elastic stability. This section will be of wide interest to structural designers, as it contains a number of topics not readily available elsewhere in a practical form. In dealing with the elastic problems of structures such as simple beams, continuous and redundant frames, torsion of members, and plate and shell problems, author shows where exact solutions are possible and where approximate methods are permissible. Limits of accuracy between exact and approximate methods are clearly brought out in order to familiarize the designer with the potentialities of the procedure. Thus, in the case of a simply supported beam with uniformly distributed load, the difference between the commonly used expression and the more exact one for deflection at center is clearly pointed out, and the limit of practical use indicated, viz., that the exact expression becomes valid only for short heavily loaded beams where deformation is primarily due to shear.

The last part covers problems similar to those in the second part, but falling within the unstable domain, that is, problems in elastic instability. This section contains three chapters on columns, beam columns, and instability of plates and shells. In view of the fact that a colossal amount of literature has now accumulated on the subject of elastic instability, reviewer feels this treatment to be very brief and sketchy.

All chapters have a short bibliography for reference. Though not exhaustive, there are some striking omissions in these, such as Hetenyi's "Beams on elastic foundations," Univ. of Mich. Press, 1946, chap. 10; Pippard's "Studies in elastic structures," Arnold, 1952, part two; Bleich's "Buckling strength of metal structures," McGraw-Hill, 1952; and Watter and Lincoln's "Strength of stainless steel structural members," Allegheny Ludlum Steel Corp., Pittsburgh, 1950, the last part. Since author intended to unite the principles of strength of materials with advanced theoretical elasticity, the inclusion of topics on the applications of the theory of plasticity to engineering problems, sandwich design, and the utility of space frames and tension-field girders would have been a great asset. Nevertheless, within the limits set forth by the author, book forms a useful compendium of information on the subject of elastic behavior of engineering structures.

S. K. Ghaswala, India

Rheology (Plastic, Viscoplastic Flow)

(See also Revs. 1258, 1267, 1274, 1279)

1239. **Moskvitin, V. V., On secondary plastic deformations** (in Russian), *Prikl. Mat. Mekh.* **16,** 3, 323–330, May/June 1952.

Secondary plastic deformation is defined by author as plastic deformation which can appear after unloading of a body, previously brought to a plastic state. Author's definition is not particularly good. Il'yushin [*Prikl. Mat. Mekh.* **7,** 4, 1933] has considered the case where, after unloading, the state is purely elastic. In this article, author treats the following problem: By external forces, the whole body is brought beyond the yield point, giving rise to a tensor of stress Π, a tensor of strain γ, a tensor of plastic strain γ_p, and the body behaving throughout according to the law of Saint Venant-Mises with linear strain-hardening. After unloading, there may be a region of secondary plastic deformation in the body, described by a tensor of strain γ' and a tensor of stress Π', and a region of elastic deformation γ'' with the state of stress Π''.

It is supposed that Π' is determined according to the law of Saint Venant-Mises by $\gamma' - \gamma_p = \gamma'''$. The linear invariants of Π and the tensor of total deformation γ (elastic + plastic) being proportional, γ_p can be expressed by Π (author uses the corresponding formulas of Il'yushin, "Plasticity," 1948). Then, the deviator of $\Pi - \Pi'$ can be expressed by γ and γ''', and $\Pi - \Pi''$ by $\gamma - \gamma''$. Next, the author supposes that $\gamma = \gamma_\varphi{}^*$, where γ^* is a function of the coordinates only, and φ a function of the external forces and the constants of the material only; analogously, it is supposed that $\gamma' = \gamma_\psi{}^*$ and $\gamma'' = \gamma_\eta{}^*$. For $\Pi_0 = \Pi - \Pi'$ and $\gamma_0 = \gamma - \gamma'$, the equations of Saint Venant-Mises result; for $\Pi_\infty = \Pi - \Pi''$ and $\gamma_\infty = \gamma - \gamma''$, the equations of elasticity; γ_0 and γ_∞ fulfill the conditions of compatibility. Π_0 and Π_∞ can be considered as stresses of a fictitious body loaded in part elastically, and in part plastically, by forces acting upon the real body before unloading. Also, for the fictitious body, linear strain-hardening results with a yield point double that of the real body. $(\operatorname{dev}\gamma)^2$ being the invariant of second degree of the deviator of γ, geometric inspection suggests the following equation for the tensor of deformation γ as the yield point

$$((\operatorname{dev}\bar{\gamma})^2)^{1/2} = \left|((\operatorname{dev}\bar{\gamma})^2)^{1/2} - 2((\operatorname{dev}\bar{\gamma}_{el})^2)^{1/2}\right|$$

γ_{el} being the tensor of strain of the real body, when it reaches the yield point during its loading. At the surface of the fictitious body, separating the elastic from the plastic region, the corresponding condition holds for dev $\bar{\gamma}'$ and affects $\eta = \psi$; one can find in the fictitious body the said separation surface, fulfilling the condition $\Pi_0 = \Pi_{00}$. Also at the surface of the real body, separating elastic and plastic regions, it results that $\Pi_0 = \Pi_{00}$.

Author states the following theorem: By solving in the fictitious body the elastic and plastic problem for Π_0 and Π_{00}, one can compute Π' and Π'', using $\Pi' = \Pi - \Pi_0$ and $\Pi'' = \Pi - \Pi_{00}$.

As an example, a thick hollow ball is considered, plastically deformed by internal pressure and thereafter unloaded. For the ratio of radii 2.5, a pressure of 2.227 times elastic yield stress, and a coefficient of strain-hardening λ, defined by

$$((\text{dev } \Pi)^2)^{1/2} = \lambda((\text{dev } \Pi_{el})^2)^{1/2} + 3G(1 - \lambda)((\text{dev } \gamma)^2)^{1/2}$$

and $\lambda = 0.95$, a region of secondary plastic deformation occurs within the 1.3 fold inner radius; in this case, after unloading, there results at the inner boundary a circumferential stress of about fourfold the amount of stress resulting during the said pressure. H. Schlechtweg, Germany

1240. Kammerer, A., Mechanical properties of real solids and the theory of elasticity [Les propriétés mécaniques des solides réels et la théorie de l'élasticité], Paris, Hermann et Cie, Actual. Sci. Ind., no. 1161, 1951, 132 pp. 1125 Fr. fr.

In the introduction, author states his aims as follows: (1) To review the results of mechanical tests on various materials; (2) to derive simple mathematical formulas describing these results; (3) to use a generalized version of these formulas to broaden the foundations of the theory of elasticity. The present review is restricted to the items of mathematical interest. The author begins by establishing the fundamental equations for a linear viscoelastic solid with two elastic constants and two coefficients of viscosity. No reference is made to the considerable body of classical and recent literature on this subject [see, e.g., T. Alfrey, AMR **3,** Rev. 2344]. Next, the idea is introduced that an initially isotropic material may become orthotropic under strain, even within the elastic range. It is assumed that Young's modulus for each principal direction of strain depends in a linear fashion on the corresponding principal strain and the cubical dilatation. It is claimed that, within a certain range at least, the influence of temperature is adequately represented if these strain terms include the thermal expansion. The resulting formulas are applied to simple tension, flexure, and torsion; the algebraic work is simplified by the startling assumption that only the change of volume gives rise to viscous stresses but not the change of shape. For a specimen suddenly subjected to a tensile stress that is kept thereafter constant, two critical stresses σ' and σ'' are obtained: for $\sigma < \sigma'$, the extension remains finite; for $\sigma' < \sigma < \sigma''$, the extension grows indefinitely within a finite period of time; for $\sigma > \sigma''$, even the instantaneous extension accompanying the application of the load becomes infinite. Similar critical loads are obtained for flexure and torsion. In discussing the behavior of a solid subjected to a homogeneous state of stress, author drops the viscous terms to achieve greater mathematical simplicity. Again, critical conditions of loading are determined that lead to infinite strains. In the opinion of this reviewer, such attempts at obtaining the condition of rupture by extrapolating laws of elasticity far beyond their range of validity cannot be justified by physical arguments. The same remark applies to the author's theory of endurance.

Courtesy of Mathematical Reviews W. Prager, USA

1241. Andrade, E. N. da C., and Jolliffe, K. H., The flow of polycrystalline metals under simple shear, *Proc. roy. Soc. Lond.* (*A*) **213,** 1112, 3–26, June 1952.

In the usual creep test in tension, the stress system resolves into a trivial hydrostatic tension and two superposed shears. To obtain creep under simple shear, authors used method in which a constant couple is applied to an annulus cut in a thicker disk of the metal. Tests were made on commercial lead, pure lead, and cadmium at 25 C and occasionally at temperatures up to 140 C. All materials showed elongation proportional to $t^{1/3}$, with no linear term in time t such as occurs in tensile test. Pure lead recrystallizes after a certain strain, and creep then accelerates.

On reversing the stress, lead gives creep linear in t, and a second reversal on reaching zero total strain gives a more rapid linear creep. Cadmium gives $t^{1/3}$ creep on both first and second reversals.

The results are discussed in terms of two mechanisms of creep: glide within the grains, which produces the transient $t^{1/3}$ component, and glide of grains over their neighbors, which produces the steady-state t component. The different behaviors of lead and cadmium on reversing the stress are explained by the argument that lead work-hardens rapidly, so that glide within grains is suppressed in second test, while cadmium, with a hexagonal lattice, work-hardens very slowly and can creep in repeated tests by same mechanism as in original test.

F. R. N. Nabarro, England

1242. Arutyunyan, N. Kh., Some problems of creep theory (in Russian), *Prikl. Mat. Mekh.* **16,** 3, 257–270, May/June 1952.

This is the second part of author's work on the creep in concrete members [see AMR **4,** Rev. 252]. Nonlinear creep is discussed in the region above 0.5 U.T.S., the region in which, according to author, nonlinear creep occurs. The principle of superposition is assumed for elastic deformation and deformation due to creep. The elastic modulus is considered to be a function of time.

Creep is defined by two functions. The first, found experimentally, is a function of applied load. The second, a function of two time variables (time τ measured from the formation of concrete, and time t measured from the application of the load), is of the form

$$C(t, \tau) = \varphi(\tau)\{1 - \exp[-\gamma(t - \tau)]\}$$

where $\varphi(\tau)$ is also an experimental function.

W. Sylwestrowicz, USA

1243. Mott, N. F., Mechanical strength and creep in metals, "Imperfections in nearly perfect crystals," New York, John Wiley & Sons, Inc., 173–190, 1952. $7.50.

Mott summarizes the effects responsible for the mechanical strength of metals. The effects considered are: (1) The influence of impurities on the motion of dislocations. In this section, the effect of Preston-Guinier zones, Cottrell locking, and the effect of dissolved atoms on the motion of dislocations are considered. (2) The strength of metals at moderate temperatures and rates of strain. This section contains a discussion of the strength of pure metals in terms of the distance between two locking points of a Frank-Read source. (3) Exhaustion creep. The theory of exhaustion creep considered is that of Mott and Nabarro. This theory is compared with experiments by Davis and Thompson.

M. A. Meyer, South Africa

1244. Diehl, J., and Kochendörfer, A., Tensile deformation of single crystals with rotatable grips (in German), *Z. angew. Phys.* **4,** 7, 241–247, July 1952.

When a long single crystal is extended, the central parts rotate,

but the ends are constrained by the grips and cannot rotate. It seemed possible that the bending occurring at the junction of these two regions could affect the stress-strain curve. Authors devised a tensile machine of the Polanyi constant strain-rate type, with grips free to rotate about an axis normal to tensile axis and to expected glide direction. Observed rotation of grips agreed with that calculated only when axis of rotation lay in or near glide plane. Crystals of 99.998% aluminum with these orientations were cut in half. One half was tested with rotatable grips, other half with conventional rigid grips, at same strain rate. Stress-strain curves for both halves were almost identical, rigid grips producing a very small increase in hardening. The hardening of latent glide systems, the rate of recovery, and the Laue asterism were also equal for the two halves.

F. R. N. Nabarro, England

1245. **Mott, N. F., Mechanism of work-hardening of metals,** *Engineer, Lond.* **194,** 5052, 694–697, Nov. 21, 1952.

The evidence for the existence of vacant lattice sites and dislocations in crystals is reviewed, and their roles in diffusion and crystal growth are discussed. Slip bands are described in terms of dislocations, and a dislocation model of the plastic deformation and work-hardening processes is proposed.

J. C. Fisher, USA

1246. **Chalmers, B., and Martius, Ursula M., Slip planes and the energy of dislocations,** *Proc. roy. Soc. Lond.* (*A*) **213,** 1113, 175–185, June 1952.

Paper demonstrates that active slip planes and slip directions in a metal crystal are those corresponding to minimum energy of dislocation formation. Since the strain energy associated with a dislocation is a direct function of the ratio ion-spacing-in-direction of slip/ion-spacing normal to plane of slip = β, the slip system of least energy will be that for which β is a minimum. Values of β for different slip systems are computed, and it is shown that those corresponding to minimum β correspond to those that are observed to be active in each case. In those instances where a second slip system becomes active, this second system corresponds to the second smallest value of β. M. C. Shaw, USA

1247. **Joly, M., Theory of the orientation of mutually interacting rigid particles** (in German), *Kolloid Z.* **126,** 2/3, 77–87, May 1952.

The well-known theory of Boeder for the orientation of rigid anisotropic particles in a field of flow is extended to the case where the interaction of the particles has to be taken into account. This is accomplished in an approximate way by the introduction of an extra angular velocity which is assumed to be directly related to the energy of interaction. As a result, it is concluded that the influence of the interaction may be described by a modified value of the rotation-diffusion constant. This result is applied to various optical and rheological properties of the system.

H. C. Brinkman, Indonesia

1248. **Rachinger, W. A., The effect of grain-size on the structural changes produced in aluminium by slow deformation,** *J. Inst. Metals* **80,** 415–418, 1951–1952.

Specimens of aluminum, 99.98% having grain sizes from 0.2 to 1 mm and 2 or 3 crystals within the gage length, have been subjected to tension at 250°, 350°, and 400° with a rate of elongation of 0.15% per hr. Previous results with fine-grained material were corroborated. The grain size of the subcrystals (substructure) increases with increasing temperature. The subunits sometimes had the appearance of bands perpendicular to the slip lines. In coarser material, a breakdown into cells was observed, which was not the case with fine-grained material. For a given temperature, the slip was the stronger the larger the crystallites. The increase of grain size is equivalent to the lowering of the test temperature.

The tests were made using a microscope and x rays. The results correspond in general to the theoretical expectations. The formation of substructures is considered predominantly as polygonization. G. Masing, Germany

1249. **Andrade, E. N. da C., Physics of the deformation of metals** (in French), *Rev. Métall.* **49,** 7, 469–484, July 1952.

Creep in metal wires under constant stress (*not* constant load) is discussed first. Results from tests on tin, iron, copper, cadmium, and solid mercury are represented by a single equation containing two parameters, β and χ, which express two distinct mechanisms of flow—called β-flow and χ-flow. The former, characterized by a diminution in creep rate, is due to slip movements in the grains, while the latter, taking place at a constant creep rate, admits relative movement between the grains themselves and is controlled by conditions at the grain boundaries. The relative magnitudes of β and χ for different metals, temperatures, and stresses are discussed. It is shown that rapid prestraining can eliminate the β-flow by producing the modification to the grains necessary for χ-flow. The phenomenon of recrystallization is also shown to produce, on completion, χ-flow.

Author then presents recent studies on the creep of specially shaped disks subject to pure shear. Application of shear may be applied in a direct or reverse sense. Creep-time curves for a single application in one sense is represented for both lead and cadmium by a law of the same form as in the tension tests when $\chi = 0$. On reversal of shear, however, the laws for lead and cadmium differ widely. This is attributed to the different hardening abilities of the two metals. It is recorded that recrystallization takes place in the lead specimens but produces no apparent χ-flow, as in the tension case. Author suggests this is due to the comparative freedom of the grains on the surface of the wires compared to the constraints to flow in his disk specimens.

Latter part of paper is devoted to studies on single crystals. It presents experimental results illustrating marked increases in critical shear stress of silver wires which were inadvertently covered with a thin oxide film while being prepared for testing. The beneficial effects of impurities in the monocrystal specimens are emphasized. Author claims there is a connection between the phenomena of asterism and hardening, and suggests that the latter is due to the rotation of small crystalline fragments. Hardening characteristics in relation to percentage of slip and temperature are discussed.

A most informative paper, representing the opinions of an authority on the subject of deformation of metals.

M. C. Steele, Scotland

1250. **Chalmers, B., The properties and effects of grain boundaries,** "Imperfections in nearly perfect crystals," New York, John Wiley & Sons, Inc., 441–450, 1952. $7.50.

Paper discusses the effects of the nature of the grain boundaries on plastic deformation and considers the possibilities of a non-crystallographic mode of deformation. The physical properties of solids must be divided into those structure-sensitive and those nonstructure-sensitive. The first ones are those which are greatly affected by small departures from the ideal lattice; they are associated with the properties of plasticity and form the subject of the paper.

It is known that individual or single metal crystals behave differently from polycrystalline samples of the same metal, and that the plastic behavior of a polycrystalline specimen cannot be predicted directly from single-crystal data. In the latter cases, there

are no crystal boundaries, and each crystal behaves differently if it is surrounded by other crystals in contact with it. Of special interest for the investigation are the bicrystals consisting of two crystals with predetermined orientations with a common boundary; they can be produced by special methods. The processes of fusion and the chemical and electrochemical effects are investigated and references are given. T. Pöschl, Germany

1251. Schwarzl, F., and Staverman, A. J., Time-temperature dependence of linear viscoelastic behavior, *J. appl. Phys.* **23,** 8, 838–843, Aug. 1952.

Authors have investigated the often accepted statement that a shift in temperature is equivalent to a shift in logarithmic time scale in the study of linear viscoelastic behavior. They have called materials for which this is true thermorheologically simple (Class A), and have shown how the results of creep experiments can be used to determine whether materials are Class A or otherwise (Class B). The microrheological conditions for Class A behavior are investigated and the practical significance of the results indicated. For example, the effect of heat treatment on Class B materials may result in special structure, whereas for Class A materials no structure should result which could not be obtained by one temperature. Authors suggest Class A polymers would not contain crystallites or pronounced polar groups.

D. G. Ivey, Canada

1252. Koehler, J. S., The influence of dislocations and impurities on the damping and the elastic constants of metal single crystals, "Imperfections in nearly perfect crystals," New York, John Wiley & Sons, Inc., 197–216, 1952. $7.50.

Paper discusses the theoretical explanation of two phenomena observed in experiments with metallic single crystals at frequencies in the kilocycle range: (*a*) The damping of stress waves and its dependence on the presence of impurities, on strain amplitude, and on the cold work to which the specimen has been subjected; (*b*) the decrease of elastic moduli due to cold work. After a survey of experimental results, the theory is developed on the supposition that the phenomena are associated with edge-type dislocations which are visualized as taut strings, anchored to impurity atoms by Cottrell forces; the dislocations are assumed to vibrate in their slip planes under the action of external sinusoidal shearing stresses. The differential equation of motion is set up and solved by successive approximations; the solution is used to derive expressions for the distribution of the effective free lengths of the dislocations, the effect of dislocations on the rigidity modulus, the decrement for very small strain amplitudes, and, finally, the variation of decrement and rigidity modulus with strain amplitude. When the theoretical results are compared with the experimental ones for copper, it is found necessary to assume that the damping force per unit length of a dislocation is about 100 times the value suggested by previous workers (Eshelby, Leibfried); it is pointed out, however, that this increase is qualitatively in accord with experiments on the effect of rate of strain on the (stress, strain) curve of copper. In the appendix, author discusses a suggestion, made by Reed, that the motion of screw dislocations contributes to the decrement.

R. M. Davies, Wales

1253. Read, W. T., Jr., and Shockley, W., Dislocation models of grain boundaries, "Imperfections in nearly perfect crystals," New York, John Wiley & Sons, 352–371, 1952. $7.50.

For grain boundaries joining two crystallites which have been rotated relative to one another by a small angle θ, the geometrical conditions rigidly limit the choice of the dislocation model and thus lead to definite predictions which can be compared with experiment. For any fixed arbitrary orientation of the grain boundary and axis of relative rotation of the adjoining grains, the energy per unit area satisfies the formula $E = E_0\theta\,[A - \ln\theta]$, where E_0 and A are parameters dependent on the model. E_0 is calculable directly from the elastic constants and the dislocation model, and A requires, in addition, the energy of atomic disorder at the core of a dislocation. The available experimental curves of relative E vs. θ for silicon-iron, tin, and lead are in good agreement with the formula, even for values of θ larger than are justified by the derivation. A theoretical estimate of the absolute energy of a random grain boundary in copper agrees within 30% with the average experimental values. The difference between energy and free energy is shown to be unimportant for boundaries with small θ.

From authors' summary by Evan A. Davis, USA

1254. Hu, L., and Marin J., Determination of theoretical plastic stress-strain relations for variable combined stress ratios, *J. appl. Mech.* **19,** 4, 485–488, Dec. 1952.

Paper presents analytical procedure for determination of combined plastic stress-strain relations, based upon simple tension relations, for case of principal stress (1) constant, (2) varying, and (3) zero. Theory is in fair agreement with one experiment from previous paper [Marin and Kotalik, AMR **4,** Rev. 2929].

Robert B. Green, USA

1255. Marin, J., and Wiseman, H. A. B., Plastic stress-strain relations for combined tension and compression, *NACA TN* 2737, 61 pp., July 1952.

Authors test thin-walled tubes of aluminum alloy (4.4% Cu, 0.8% Si, 0.8% Mn, 0.4% Mg) under combined tension and torsion. Tests with constant ratio of principal stresses do not distinguish between the incremental and total strain theories. Tests with variable stress ratios using different loading paths are in better agreement with incremental strain theory than total strain theory. Specimens lose isotropy during strain hardening. Measurements with strain rosette show that directions of principal stresses and strains do not coincide during plastic deformation. H. Mussmann, Germany

Failure, Mechanics of Solid State

(See also Revs. 1212, 1213, 1266, 1268, 1276, 1280)

1256. Kuntze, W., Conditions for brittle failure in metals and steel (in German), *Stahlbau* **21,** 9, 159–164, Sept. 1952.

Kuntze suggests that the transition from the elastic to the plastic range requires a certain amount of time (relaxation time) which is characteristic of the metal. If the rate of deformation is greater than the rate of stress relaxation, then the metal is brittle; if the rate of deformation is less than the rate of stress relaxation, the metal is ductile. Brittle failure in steel, cast iron, and light metals is discussed in terms of this hyp .. esis.

M. A. Meyer, South Africa

1257. Ripling, E. J., and Baldwin, W. M., Jr., Rheotropic embrittlement of steel, *Trans. Amer. Soc. Metals* **43,** 778–805, 1951.

The term "rheotropic embrittlement" was introduced to describe a type of brittleness under severe service conditions which can be overcome by cold working under mild service conditions.

A large part of the low-temperature ductility deficiency of SAE 1340 when furnace-cooled as well as when quenched and tempered in the vicinity of 600 F was found to be rheotropic. The low notched ductility of SAE 1340 at high strength levels was also shown to be a result of this type of brittleness.

Rheotropic embrittlement was found to account for the dangerously high transition temperature in both heat-treated SAE 1340 and annealed steels.

The condition which causes this type of brittleness was shown to be either not cumulative under low-temperature straining, or else cumulative but readily washed out by room-temperature deformation. From authors' summary

1258. **Shaw, M. C., A yield criterion for ductile metals based upon atomic structure,** *J. Franklin Inst.* **254, 2, 109–126, Aug. 1952.**

A theory of yield for ductile metals is proposed which takes into account a uniform distribution of inhomogeneities. The new theory predicts a variation in yield stress with specimen size, and that such size effect will occur in torsion specimens but not in tension. The theoretical results are compared with experimental results of Morrison, whose results are quoted incorrectly and in a somewhat misleading way. The general conclusions of the paper are not, however, affected by this. The size effects in fatigue testing and hardness testing are discussed, and the relation of the new theory for ductile material to the theory of Weibull for brittle materials is considered. W. M. Shepherd, England

1259. **Murray, W. M., edited by, Fatigue and fracture of metals,** Symposium at Mass. Inst. Technol., June 1950, Technology Press, Mass. Inst. Technol.; New York, John Wiley & Sons, Inc., 1952, viii + 313 pp. 86.

Book is a survey of present state of knowledge and expert opinion, which reviewer believes will be most valuable to designers and researchers in the field. Extensive bibliographies are given. Reviewer regrets some report could not be included of the beginnings of most basic work started in recent years, using methods of chemical physics and modern physics.

General survey of the problem of fatigue and fracture, by M. Gensamer. Article is brief statement in readable form of present empirical knowledge of fatigue and of change from ductile to brittle behavior with decreasing temperature. Simple explanations are given where possible. Reviewer recommends it to practicing engineer. Observed facts of fatigue are listed. Fatigue is viewed as "a race between hardening and damage." Transition from ductile to brittle fracture and transition temperature are discussed, considering speed, grain size, microstructure, size and geometry of specimen, and type of test. Author recommends either minimum of 15 foot-pounds energy absorption in V-notch Charpy test at service temperature or transition temperature 50 F below service temperature in keyhole Charpy test as design criterion for steel in structures.

The fatigue problem in airplane structures, by H. L. Dryden, R. V. Rhode, and P. Kuhn. Fatigue problem is of air frame only, with emphasis on attempt to provide a quantitative basis for design and operation. Methods are proposed and data are presented concerning gust-load magnitudes and frequencies and the response of the structure. Methods and data are given for S-N curves with mean stress not zero, for effect of stress raisers under all stress conditions, for effect of cumulative fatigue damage under irregular loading. Authors tentatively conclude that Neuber relation describes correctly the size effect of notches. Periodic variation of stress amplitude with nearly equal frequency of various stress levels gave $\Sigma\, n/N$ about 0.8; with frequency of low stress levels relatively greater, value was about 1.6. Curves are given showing effects on fatigue life for one typical air frame of stress-concentration factor, design air speed, etc. Authors conclude it may never be possible to make accurate quantitative predictions of fatigue life, but express the hope that relative effects of many of the variables may be found.

Brittle fracture and fatigue in ships, by Finn Jonassen. Of 5000 all-welded ships built, "approximately 1000 ships have sustained fractures." These were essentially brittle failures. Photographs of fractures and statistics of failures are given. Author concludes that fatigue has not been important factor in failures. Elimination of stress raisers by control of design and workmanship improves safety of welded structure, but, in addition, material must be notch-tough at operating temperatures. Results are shown of various energy-to-fracture tests. Transition temperature rises with increasing plate thickness. Lower carbon, higher manganese steels have lower transition temperatures, as do fully killed, fine-grained steels. No adequate steel specification has been set up. Riveted crack arrestors are effective in limiting cleavage fractures.

Brittle fracture and fatigue in machinery, by R. E. Peterson. In a form immediately applicable to engineering design of parts subject to fatigue, paper presents data, formulas, and curves. These include fatigue notch factors, generalized S-N curves for notched and unnotched specimens in axial alternating stress and in rotating beam stress, effect of mean stress for notched and notch-free specimens, and one tension-compression fatigue diagram for a cast iron. Photographs of fatigue failures are shown. A three-dimensional fatigue-failure model for axial stress conditions is shown in several views.

Internal stresses and fatigue, by O. J. Horger and H. R. Neifert. Report of continuing research. Purpose is to correlate fatigue properties with residual stresses determined in heavy wheel axles by Sachs' boring-out method. Residual stresses were produced by 22 methods of heat treatment or surface preparation of SAE 1050 steel shafts, and measured after bending fatigue. Results are shown in tables and graphs. No definite correlation can be made, but work continues. Paper discusses earlier results in literature, indicating that residual stresses fade and change during fatigue.

Designing for fatigue, by R. L. Templin. Critical discussion is given of common design procedures, with four aluminum alloys taken for examples in S-N curves smooth, notched, riveted, and in riveted box beams. Author states: "There is considerable evidence indicating that changes in design or fabrication practices are often more effective in improving fatigue strength than is choice of metal." Design includes selection of material, designing shape of part, specifying fabrication and processing, and writing operation and maintenance instructions.

Fundamentals of brittle behavior in metals, by Egon Orowan. Clear presentation and extension of macroscopic theory of notch brittleness mention decrease of temperature, increase of strain rate, an[illegible]tic superstressing as leading to brittle fracture. Author discusses thoroughly influence of plastic constraint, or triaxial tension, and limit of constraint factor to about 3. Davidenkov and Wittman explanation of transition temperature is modified by some remaining plastic deformation. Author proposes condition of brittle fracture in ductile but notch-brittle metal to be Griffith fracture condition with surface energy replaced by plastic work per unit of area of fracture surface, such work being found to be localized in a thin layer. This gives critical crack length of order of one millimeter for mild steel. Often a crack must lengthen and sharpen by ductile fracture until brittle fracture stress from the modified Griffith condition drops to highest tensile stress present in plastic deformation. Thus, brittle strength and transition temperature are not fixed properties but depend on cracks present or possible by plastic growth. Reviewer believes proposed modified Griffith condition to be a useful tool which advances the understanding of notch-brittle phenomena.

Experimental study of temper brittleness of slightly alloyed carbon steel, by P. A. Jacquet and A. R. Weill. Paper shows

that tough and brittle states of a nickel-chromium steel, due to different tempering and cooling, can be distinguished after electrolytic polishing by micrography, x-ray diffraction, and microhardness. Not only grain boundaries but also bulk matrix are involved. Confirmation of transformation revertibility is obtained and explained. Effect of a carbide stabilizer, here molybdenum, is shown and explained. Authors propose that a reversible reaction occurs between ferritic matrix and various carbides, involving carbon diffusion.

The statistical aspect of fatigue failures and its consequences, by W. Weibull. Article proposes that if P-S-N curves could be represented by general analytical expressions for S-N and either P-S or P-N, then the number of tests required to establish parameters of the known functions for given accuracy would be far less than the number required to also find and prove a function for any new material. Without claiming to have yet established such functions for all materials and conditions, author gives functions which fit well 108 rotating beam tests run at 12 loads on Bofors steel FR86. He suggests use of statistical means to analyze some components out of the complex problem and so reduce scatter and number of tests. See also AMR **3**, Rev. 1098, and AMR **4**, Rev. 2045.

A review of cumulative damage in fatigue, by N. M. Newmark. Strain hardening, changes of residual stress, local failures, and healing occur during fatigue. Damage is defined by arbitrarily selecting a damage-vs.-cycle ratio curve for one stress level. Then it is possible by tests at that level followed by second level to determine damage curve for any second-stress level. After curves are found, fatigue at various levels is treated by moving at constant damage between curves when stress level is changed. If all curves are the same, $\Sigma\ n/N$ is unity at failure, but this usually is not the case. Theoretical solution for small increments at two levels shows cumulative cycle ratio less than one, decreasing for curves farther apart, least for any two stress levels when equal blocks are taken of each. Axial tests with equal blocks show excellent agreement using mean curves, poorer agreement using maximum difference curve. Author concludes that present design is best when based upon $\Sigma\ n/N$ value of unity or somewhat less, expecting larger scatter than at one stress level. He reports limited tests indicating cyclic prestressing is less effective in extending fatigue life than single overload. He discusses problems of obtaining pattern of stress variation, random vs. systematic variation, coaxing, etc. Reviewer believes paper presents useful phenomenological approach to fatigue.

Significance of transition temperature in fatigue, by C. W. MacGregor. Definitions and tests for transition temperature are reviewed. In M.I.T. slow-bend test, it is defined as highest temperature for no macroscopic plastic flow under given fixed strain rate and constraint. Strain rate is shown to relate to transition temperature by equation analogous to chemical physics reaction-rate relation, one set of parameters for each material and constraint. Various factors affecting transition temperature are tabulated. Fatigue cycles both above and below endurance limit stress are shown to increase transition temperature in SAE 1020 steel, very great effect at first decreasing to about half of fatigue life, then increasing. Author discusses whether this is due to fatigue cracks or plastic flow, and offers suggestions for further research.

The influence of metallographic structure on fatigue, by P. L. Teed. Complex structure of real metals is shown and described. Fatigue mechanism involves localized plastic flow, work hardening, and cracking. Local stress concentrations permit plastic flow even at low stresses. Grain size does not affect fatigue of ferritic steels, but larger grains do decrease fatigue resistance of austenitic steels and nonferrous alloys, not necessarily to the same extent as tensile strength. Author suggests grain boundaries may slow crack growth. Precipitation-hardening alloys do not improve fatigue resistance much, if any, by full heat treatment. Inclusions are discussed. Their effect varies with size, shape, number, distribution, and physical characteristics relative to containing alloy. Often they are harmful, sometimes have no effect. Residual stresses are mentioned. Cold work increases fatigue limit of carbon steels almost as much as tensile strength; wrought aluminum is little affected; copper and copper alloys are helped some. Article closes with disparaging remarks about the dislocation theory.

Fatigue at elevated temperatures, by N. J. Grant. Complex problem at or above minimum recrystallization temperature. Effect of machine speed is the all-important strain rate, when high changing intercrystalline to transcrystalline fracture, and greatly affecting strength within either fracture range. No fatigue limit exists. Effect of grain size changes, fine grain is strongest for transcrystalline, coarse for intercrystalline fracture. Effect of stress and strain-rate gradients, multiaxial stresses, nonzero mean stress, and surface and structural instability are not understood.

The techniques of physical metallurgy for studying fatigue damage, by J. T. Norton. Microscope permits detailed observation of plastic flow in slip bands and shows geometry is same for static and cyclic loading. X-ray method gives qualitative values for extent of plastic deformation, may extend knowledge of basic nature of deformation. Can measure macroscopic residual stress in quantitative manner. Magnetic method, limited to ferromagnetic materials, gives average indication of developments in large volume. Plastic deformation and internal microstresses are related. Safe stress range is when microstresses rise to limiting value and remain constant; unsafe when, after possible temporary equilibrium, they increase again until failure. Damping test is extraordinarily sensitive in observing one aspect of plastic deformation, but averages over entire specimen. There is no method which can assess exact state of fatigue damage and predict its approach to failure. Robert B. Green, USA

1260. Kuhn, P., and Hardrath, H. F., An engineering method for estimating notch-size effect in fatigue tests on steel, *NACA TN* 2805, 35 pp., Oct. 1952.

Neuber's proposed method of calculating a "practical" factor of stress concentration for parts containing notches of arbitrary size depends on the knowledge of a "new material constant" which can be established only indirectly. In this paper, the new constant has been evaluated empirically for a large variety of steels from fatigue tests reported in the literature, attention being confined to stresses near the endurance limit; reasonably satisfactory results were obtained with the assumption that the constant depends only on the tensile strength of the steel. Even in cases where the notches were cracks of which only the depth was known, reasonably satisfactory agreement was found between calculated and experimental factors. It is also shown that the material constant can be used in an empirical formula to estimate the size effect on unnotched specimens tested in bending fatigue.

From authors' summary by T. J. Dolan, USA

1261. Puttick, K. E., and Thring, M. W., Effect of specimen length on the strength of a material with random flaws, *J. Iron Steel Inst.* **172,** part 1, 56–61, Sept. 1952.

Statistical strength properties and materials under tension test are discussed, under assumption the test piece behaves like chain. Consequence of two distributions considered is (1) that distribution is normal, a model for material homogeneous on scale of test; (2) that there is small number of randomly spaced lengths whose strengths are much smaller than the rest, a model for material with defects whose size is small compared with test

length, but whose mean distance apart is comparable with it. Model for (1) predicts a continuous decrease in mean test result and standard deviation with increase in specimen length. Latter model (2) predicts continuous decrease in mean, but maximum for standard deviation for specimen length for which probability of including at least one flaw is one half.

Experimental data on cold-drawn phosphor-bronze wire are presented which show model (2) gives better description of variation of standard deviation and mean with test length. Mean spacing of flaws is calculated to be about 3 in.

D. E. Hardenbergh, USA

Material Test Techniques

(See also Revs. 1224, 1241, 1258, 1269)

1262. **Pardue, T. E., and Goldberg, B., Measurement of the resistance of materials to mechanical shock,** *Proc. Soc. exp. Stress Anal.* **10,** 1, 147–156, 1952.

Paper describes an investigation of the resistance of 6 sand-cast aluminum alloys to withstand a relatively small number of mechanical shock cycles involving large plastic strains. The work adapted the Taft-Pierce Navy high-impact shock machine for this purpose. The results are compared with the standard Charpy and Izod and standard tensile tests.

C. O. Dohrenwend, USA

1263. **Hall, W. J., and Sinnamon, G. K., A mechanism for controlling large-scale fatigue testing machines,** *Proc. Soc. exp. Stress Anal.* **10,** 1, 203–208, 1952.

This permits the changing of the mean stress and the range of stress of a 50,000-lb axial fatigue-testing machine while the machine is in operation. The axial testing machine modified consisted of a variable throw crank which applied a force to the specimen amplified by a 10-to-1 lever.

The mechanism permits the crank throw to be varied by replacing the simple crank with a quadric crank; the one link is rotated by a motor and the vertical throw of the driving pin is controlled by changing the length of the stationary link. The mean stress is changed by a motor-driven turnbuckle. Thus, with suitable automatic controls, the stress cycle can be varied during the test to study the effect of variation of stress cycle on the accumulation of fatigue damage.

The quadric-crank mechanism seems eminently suited to this application. G. Sines, USA

1264. **Lutsch, A., A simple method for measuring elastic constants by means of ultrasonic impulses** (in German), *Z. angew. Phys.* **4,** 5, 166–168, May 1952.

Ultrasonic pulses with frequencies of 0.5–5 mc are sent into cylindrical specimens (p.c. 6.5-cm diam, 32 cm long) with an ultrasonic test apparatus (similar to that of Firestone). The traveling times of the longitudinal wave and of the transversal wave originating in reflecting the original *L*-wave by the end of the cylinder are measured. The geometrical data of the specimen and the measured times allow determination of sound velocities and Poisson's ratio. O. Ruediger, Germany

1265. **Bühler, H., Determination of residual stresses in finished pieces** (in German), *Arch. Eisenhüttenw.* **23,** 7/8, 293–297, July/Aug. 1952.

Paper deals with possibility of determining residual stresses in cylinders. Sachs drilling technique is used. Tests prove that value and distribution of residual stresses at end of cylinder are approximately the same as in the midlength, provided that the length is at least twice the diameter.

Author proposes, in order to determine residual stresses in cylinders, to make them longer by about 2 diam; this part can be cut off for application of Sachs drilling method. Similar results have been obtained on tubes. W. Soete, Belgium

Mechanical Properties of Specific Materials

(See also Revs. 1160, 1241, 1242, 1243, 1244, 1245, 1248, 1249, 1250, 1252, 1255, 1257, 1259, 1395, 1408, 1450)

1266. **MacGregor, C. W., and Grossman, N., Effects of cyclic loading on mechanical behavior of 24S–T4 and 75S–T6 aluminum alloys and SAE 4130 steel,** *NACA TN* 2812, 53 pp., Oct. 1952.

An investigation was conducted to determine the effects of cyclic loading on the mechanical behavior of 24S–T4 and 75S–T6 aluminum alloys and SAE 4130 steel. Specimens of the three materials were subjected to various numbers of prior fatigue cycles both below and above the fatigue limits. Special slow-bend tests at constant deflection rates and temperatures were employed to show the effects of prior cycles of fatigue stressing on the transition temperature to brittle fracture for SAE 4130 steel, and on the energy-absorption capacity of the aluminum alloys. Micrographic studies were made to observe and measure crack formation and propagation, and additional special tests were conducted to supplement the results of the slow-bend tests. These included Charpy impact tests, microhardness surveys, tension tests, and fretting-corrosion studies. From authors' summary

1267. **Sander, H.-R., and Hempel, M., Tension-compression fatigue strength and property changes of steel after cold deformation with various velocities** (in German), *Arch. Eisenhüttenw.* **23,** 7/8, 299–320, July/Aug. 1952.

Investigation reports results of studying effects of prior deformation, produced by a variety of strain rates, on the endurance limit of several ferrous metals; correlations with other properties are also reported.

Materials investigated were a soft iron (0.02% C, 0.05% Si, 0.07% Mn); a carbon steel (0.4% C); an unstabilized 18-8 austenitic steel; a Ti-stabilized austenitic steel (15% Cr-27% Ni). Strain rates from 0.005 to 20,000%/sec were used.

The change in fatigue strength was found to depend upon the total prior strain, the strain rate, and the metal tested. The fatigue-strength/tensile-strength ratio was determined for increasing cycles of loading and increasing amounts of prior deformation. Metals whose dynamic yield point is higher than static yield point were found to show a greater increase in fatigue strength after prior dynamic straining than after static straining. There was found to be less transformation of austenite to martensite in the 18-8 stainless when strained dynamically than when strained statically. Residual surface compressive stresses were found to be higher after dynamic than after static stressing. An aging treatment at 230 C after straining raised the fatigue strength. A stress-relief anneal at 520 C did not reduce fatigue strength.

Paper describes apparatus for high-velocity straining in which firing of a cartridge produces the force required for prior straining.

Carl A. Keyser, USA

1268. **Love, R. J., The influence of surface condition on the fatigue strength of steel,** Symp. Proper. metall. Surf., Institute of Metals, London, 161–196, Nov. 1952.

A concise review of 157 references on the various surface treat-

ments and conditions influencing the fatigue strength of steels. Beneficial surface treatments such as carbonizing, nitriding, cyaniding, flame hardening, and cold work by rolling, pressing, or presetting are compared with surface roughness, decarburization, cold straightening, nonferrous coatings, sprayed-on steel coatings, and acid pickling, all of which tend to lower the fatigue life. Author concludes that shot-peening has little effect on fatigue life, although his tabulated results of shot-peening show, in some instances, considerable improvement. Paper is an excellent summary of the work of the major investigators and should be of great value to designers and engineers who want an over-all review of the effects of surface preparation on fatigue life of steels.

E. E. Sechler, USA

1269. Dowd, J. D., Weld cracking of aluminum alloys, *Welding J.* **31,** 10, 448s–456s, Oct. 1952.

A test has been developed for evaluating crack sensitivity of welds in aluminum alloys. Crack sensitivities of nonheat-treatable aluminum-magnesium alloys, 4S-0, 52S-0, XA54S-0, and X56S-0; the medium-strength heat-treatable aluminum-magnesium silicide alloys, 53S-T6, and 61S-T6, and 62S-T6; and the high-strength heat-treatable alloys, Alclad 14S-T6, Alclad 24S-T4, and Alclad 75S-T6, welded with various filler alloys have been evaluated. Filler alloys tested, 43S and no. 716 brazing wire, gave the least amount of cracking in all of the plate compositions. Welds made with these alloys have low ductility and frequently low tensile strengths. Welds made with aluminum-magnesium filler alloys containing up to 10% magnesium showed, in general, decreasing susceptibility to weld cracking with increasing magnesium content. Welds made in the aluminum-magnesium and the aluminum-magnesium silicide alloys with 56S filler wire and in 52S, XA54S and X56S alloys with XA54S filler wire were found to have relatively low-crack sensitivity.

From author's summary by R. K. Bernhard, USA

1270. Gille, F., Determination of the dust grain size in the cement industry (in German), *Zement-Kalk-Gips* **5,** 10, 309–315, Oct. 1952.

Article reports on methods by which the Forschungsinstitut der Zement-industrie determines the grain size of cement brands and, in particular, that of cement-dust types, and shows some microscopic photographs of these dust types.

From author's summary

1271. Ulitskiĭ, I. I., Determination of stresses in hydraulic structures arising from shrinkage of concrete (in Russian), *Gidrotekh. Stroit.* no. 8, 6–9, Aug. 1951.

Formula is developed for tension stress produced by shrinkage accompanied by plastic flow and a simultaneous growth of the modulus of elasticity, in a straight concrete member constrained to keep a constant length. The three actions are assumed to be functions of time, obeying the same exponential law, in the presence of linear stress-strain relationship.

The formula shows that the gradual development of shrinkage results in great reduction of stress compared to a sudden application of it, while the growth of the modulus of elasticity has only a minor effect. Author attempts to relate these results to design of temperature and shrinkage reinforcement, but, as the editor correctly points out, this action is not justified.

A. Hrennikoff, Canada

1272. Borodowsky, M. S., On the question of the strength of textile materials (in German), *Faserforsch. Textiltechn.* **3,** 4, 146–154, Apr. 1952.

Author remarks that a practical judgment on yarns and fabrics cannot be based on the sole values of breaking strength and breaking extension; fatigue and abrasion tests principally have to be taken in account.

Paper is limited to considerations on repeated solicitation. The general expressions of the work developed for the different kinds of deformations, during cyclic extension, are given. It is shown how these expressions can be simplified when the ultimate values of the force or of the deformation are kept constant, and when it is supposed that the strength is a linear function of the extension. An apparatus, "the pulsator," producing a cyclic extension solicitation in yarns and fabrics, is described. It is fitted with a recording device giving the curve representing the permanent deformation in function of the number of cycles. Some applications can be deduced from these curves.

D. De Meulemeester, Belgium

1273. Andrade, E. N. da C., The effect of surface conditions on the mechanical properties of metals, mainly single crystals, Symp. Proper. metall. Surf., Institute of Metals, London, 133–143, Nov. 1952.

Thin oxide coatings on single crystals of cadmium, zinc, tin, and silver formed by exposure to atmosphere increase critical shear stress (c.s.s.) and stress for further strain. Old data show films from about 20 to 1000 atom layers increased c.s.s. from 50% to 150%. Immersion in electrolytes followed by washing and drying also affect mechanical properties of cadmium. Zinc ion increases creep rate. NO_3 decreases rate. Oxide film effect increases rapidly as single-crystal diameter decreases. For cadmium, c.s.s. was increased by film 14-fold with 0.025-mm wire; with 0.5-mm diam, about 50% increase. C.s.s. of silver in air falls as temperature is raised from −180 to 290 C, and rises as temperature goes from 200 to 600 C. There is no effect in inert gases. Effect becomes larger after some deformation has taken place. In one case, c.s.s. was increased 25% by oxide film, but after 20% glide, stress for further glide was increased 10-fold by oxide film. Author suggests that foreign surface atoms are carried in during glide. Polycrystalline metals show another surface effect limited to layer with thickness about 0.3 of average grain diameter. Effect is due to essentially zero resistance to deformation for crystals with one free surface, compared to internal crystals surrounded by others with randomly oriented glide planes.

E. Creutz, USA

1274. Rhines, F. N., and Cochart, A. W., Preview of behavior of grain boundaries in creep of aluminum bicrystals, *NACA TN* 2746, 40 pp., July 1952.

The gliding of one metal crystal with respect to another, along their mutual grain boundary, has been studied during high-temperature creep tests conducted with bicrystals of pure aluminum. Stresses of from 1 to 100 psi and temperatures from 200 to 650 C were employed. The direction of motion depends only upon the direction of the maximum resolved shear stress in the plane of the grain boundary. The magnitude of the motion increases with the magnitude of the resolved shear stress, the temperature, and the degree of mismatch between the orientations of the two crystals. The gliding rate is cyclic, increasing directly with the temperature at the beginning of the cycle, but subsequently obeying a chemical-rate law, with a computed activation energy of 9700 calories per mole. There is for each temperature a threshold stress below which gliding does not occur. At lower temperature, and where the orientation difference between the grains is small, an induction period precedes the onset of gliding. A substantial thickness of crystalline metal participates in the gliding motion and becomes fragmented and extensively disoriented in the process. During creep, the por-

tions of the grains away from the boundary also degenerate into blocks (or fibers) that move with respect to each other, parallel to the tension axis, and that rotate about octahedral axes of the original crystal. From authors' summary by L.-W. Hu, USA

1275. **Small, L., and Symon, K., Round work correction for Rockwell hardness,** *Tool Engr.* **29,** 2, 41–45, Aug. 1952.

A mathematical analysis of the effect of round specimens upon the depth of indentations made by the spheroconical Rockwell indenter is given. Correction charts are presented for Rockwell readings on round work. Corrections become increasingly important as the depth of the indentations increases with respect to the diameter of the specimen. Corrections become negligible as the load applied to the specimen decreases and as the size and hardness of the specimen increases. A. D. Schwope, USA

1276. **Hoeltje, W. C., and Newmark, N. M., Brittle strength and transition temperature of structural steel,** *Welding J.* **31,** 11, 515s–521s, Nov. 1952.

Paper presents the results of a study of the available test data regarding brittle strength and transition temperature from wide plate tests. Study includes (1) brittle strength and (2) transition-temperature range between brittle and ductile fracture. Both of these appear to be related primarily to a variable ρ, the ratio of the radius at the root of the notch to the net cross-sectional area of the specimen.

The brittle strength shows a general tendency to increase with a corresponding increase in ρ for a considerable range, which covers all values of the variable for which data could be obtained. On the other hand, the transition temperature tends to remain practically constant for all values of ρ less than some critical value, whereas above this critical value transition temperature appears to drop as ρ increases.

Some of the discrepancies that have been observed in the strength and transition temperature of small specimens relative to large specimens may arise from the influence of the parameter ρ. In general, for geometrically similar specimens, ρ is numerically larger for the smaller specimens. This, perhaps, explains why small-specimen tests are in general less severe than are tests of large specimens or tests of prototype structures.

From authors' summary

1277. **Voss, A. W., Mechanical properties of some low-density materials and sandwich cores,** *For. Prod. Lab. Rep., U. S. Dept. Agric.* no. 1826, 8 pp., 4 tables, 16 figs., Mar. 1952.

The Forest Products Laboratory has carried on research into the mechanical properties of honeycomb and other low-density core materials for sandwiches. Much of this information has already been published. This publication adds new information respecting the properties of honeycomb cores of aluminum, cotton fabric, glass fabric, and of foamed resin core materials. Densities of core materials varied approximately from 3.5 to 12 lb per cu ft. Strength values were obtained in compression, tension, and shear, under two conditions of temperature and humidity: 75 F and 64 RH, and 80 F and 97 RH. Tables of values and graphs of typical load-deformation behavior are given. This information should be of especial interest to all workers in the field of structural sandwich constructions. A. G. H. Dietz, USA

1278. **Lincoln, B., Frictional and elastic properties of high polymeric materials,** *Brit. J. appl. Phys.* **3,** 8, 260–263, Aug. 1952.

Author suggests the relation $F = KW^{2/3}$ between frictional force F and load W for high polymers under small loads. This relation, which implies elastic deformation of surface asperities, is proposed from consideration of Hertz's equations for deformation of solids in contact. Frictional measurements on nylon specimens verified this relation. Measurements of the area of contact of a nylon hemisphere pressed against a glass surface at various loads were in agreement with the assumption of elastic deformation. Effects of relative humidity, surface contamination, and surface roughness on friction of polymers, mostly nylon, were also studied. The friction coefficient of polymer fibers on cylinders decreased as the surfaces of the latter were made rougher; this is explained on the basis of elastic deformation of surface asperities.

B. M. Axilrod, USA

1279. **Hsiao, C. C., Effect of orientation on the ultimate strength of linear high polymers,** *J. appl. Phys.* **23,** 10, 1189–1190, Oct. 1952.

When the molecules of linear high polymers are oriented by tension or compression while in the heat-softened state, the mechanical properties of the plastic become anisotropic after the material has been cooled to the solid state.

Equations are listed, but not derived, for the ultimate strength of such materials when tested parallel or perpendicular to the direction of orientation. Data are given on the tensile strength of polystyrene which tend to support the validity of the theoretical equations. L. Nielsen, USA

1280. **Gurney, C., The effect of surface condition on the strength of brittle materials,** Symp. Proper. metall. Surf., Institute of Metals, London, 145–160, Nov. 1952.

Author presents new experimental data and analysis, along with related work previously published by himself and others, in a rather broad coverage of the subject. He concentrates on the first of the paper's three main divisions which are discussions of mechanical properties of glass with a defective surface, strength of glass with an undamaged surface, and the effect of surface defects on the strength of other brittle materials. It is believed that final fracture occurs when the highest effective stress at the ends of the surface cracks becomes equal to that required to pull the atoms apart. The disagreement in fracture stress from atomic and engineering standpoints can be understood in terms of the large stress concentration associated with a sharp crack end of atomic dimensions. Author's varied tests (torsion, bending, and radial pressure) yield equal fracture stresses at equal "times to fracture" in support of this crack theory. Other tests show that "delayed fracture" (rupture under constant load a short time after loading) in glass is due to attack by the atmospheric constituents, water vapor and CO_2. Author points out that glass subjected to normal handling has strength about half that of glass with perfect surface, and that plastics are less sensitive to surface damage than glass is. J. Miklowitz, USA

1281. **Marin, J., and Pao, Y.-H., On the accuracy of extrapolated creep-test relations for plexiglas subjected to various stresses,** *Trans. ASME* **74,** 7, 1231–1240, Oct. 1952.

Authors report results of 10,000-hr-duration creep tests in tension, compression, torsion, and bending. Purpose is to determine the validity of the usual extrapolations from 1000-hr-duration creep tests. The extrapolation is obtained, considering creep as consisting of two parts—a transient or recoverable part, and a nonrecoverable part which increases proportional to time. (Appendix of paper gives results of unloading specimen previously loaded in torsion or bending, results being given in support of the above breakdown of creep.) Numerical results are given which show the measured and computed 10,000 deformations. Agreement is good in general, but results are given only for low stress values, i.e., these stress values for which rupture did not occur within 10,000 hr. Reviewer believes this to be a major oversight,

limiting the validity of the conclusion, since it is precisely these values of stress which are of most concern.

D. A. Stuart, USA

1282. Hargreaves, F., Incipient corrosion of steel, *Metal Treatm.* **19, 84, 385–390, Sept. 1952.**

The initiation of corrosion and its progress have been studied, and author presents some of his findings. Filiform corrosion was induced in a polished steel specimen and its growth traced. The effect of nonmetallic inclusions and droplets of various liquids, and the influence of surface protectives were also studied.

From author's summary

1283. Parsons, K. A., A photoelastic investigation of quenching stresses in glass, *Proc. Soc. exp. Stress Anal.* **10, 1, 1–6, 1952.**

Results are reported of the photoelastic examination of three lime-glass spheres, approx. 10-cm diam, oil-quenched from 627 C to approx. 500 C. Residual quenching-stress theory of O'Rourke and Saénz [AMR **4,** Rev. 2400] is used to check measured retardations of polarized light passing through an equatorial plane of the sphere. Excellent qualitative agreement is reported, but peak relative retardations observed in two cases are about 67% of the predicted maxima. It is suggested that this may be attributed to the assumption of too low a value for the hypothetical temperature at which, in the quenching stress theory, the properties of the glass are taken to change abruptly from plastic to elastic.

L. E. Goodman, USA

Mechanics of Forming and Cutting

1284. Case, J. M., and Dew, R. E., Machining graphite for atomic energy reactors, *Machinery, Lond.* **81, 2077, 411–414, Sept. 1952.**

In this highly interesting paper, authors describe some of the graphite-machining practices. Some of the high lights are:

Woodworking tools are used in roughing operations, and carbide-tipped tools for precision finishing. In slitting, a guide twice as long as the piece to be cut is used; 3- to 6-pitch saw blade at a speed of 200 to 690 fpm is used. A woodworking planer is used occasionally; certain modifications were found necessary; thus, the metal upper rollers were covered with rubber to prevent chipping. However, it cannot be used for removing twists and bows in blocks. The thickness tolerance is held to 0.002 in. with cuts as deep as $^7/_8$ in.

For sizing operations, a fixed vacuum chuck instead of a magnetic one is used, of course, for workpieces having a flat uninterrupted surface. In grinding to a fine finish, about 0.010 in. may be removed at one pass, with a feed of 0.005 to 0.02 in. per wheel revolution; a tolerance of ±0.001 in. can be maintained. A cutting surface of the wheel was reduced to $^1/_4$ in. by forming a 45° chamfer on the inside edge.

Final forming of noncylindrical parts is made on milling machines, the tolerances ranging from ±0.005 in. Extra long end mills are used for machining 3 in., or more, wide surfaces. Cuts from 0.020 to 0.030 in. at 1400 rpm are taken.

Slits of $^1/_4$ in. × $^1/_4$ in. are taken at 1000 rpm and 16 in./min. For deeper and wider cuts, feed and speed are considerably reduced. Thus, a cut of $1^1/_2$ in. × $1^1/_2$ in. would be taken at 300 rpm and $3^1/_2$ in./min. Deep narrow cuts must be taken even more slowly.

High-speed steel drills and cutters are used. A fly cutter is specially adapted for graphite work.

All machines are equipped with flexible hose connected to an exhaust dust collector.

A short description of production of graphite balls is also given.

D. Mazkevich, USA

1285. Opitz, H., and Küsters, K., Measuring devices for determination of cutting force and cutting temperature in cutting processes (in German), *Werkstatt u. Betrieb* **85, 2, 43–47, Feb. 1952.**

Article describes dynamometer with strain gages and instruments used for investigation of turning and milling. Characteristics and calibration of electrical instruments are discussed, and design details for a special milling cutter and spindle given. Temperature-recording device and sample records are illustrated.

A. O. Schmidt, USA

1286. Epifanov, G. I., Rebinder, P. A., and Shreĭner, L. A., Effect of nature of the metal on the adsorption easing of the cutting process (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **66, 5, 879–880, 1949.**

Authors recall that their studies on tension of monocrystals in surface active media [Rebinder, Likhtman, and Maslennikov, *Dokladi* **32, 2, 1941**] showed that the adsorption action essentially results in lowering of the yield point and changing the structure of the plastically deformed crystals. Authors refer to results of their work [reviewed in AMR **6,** Revs. 920, 921].

To corroborate the title assertion, three series of samples have been investigated, again with drilling, at about 20 C: (1) Viscous plastic metals experiencing a strong hardening in cutting—aluminum and copper; (2) zinc, tin, and cadmium, which are much less plastic than the metals of the first series, and hence harden less in cutting; (3) brittle metals—bronze and cast iron—which essentially undergo only an elastic deformation not accompanied by work hardening.

All metals have been drilled dry, in pure nonpolar kerosene, and in same with additions of heptyl (concentration 343 mM/1) and cetyl (16 mM/1) alcohol, caprylic (288 mM/1) and palmitic (8 mM/1) acid. Measuring the torque M of the drill, the drilling depth and the rpm, the specific cutting work A, and the thickness h of the layer/rpm have been calculated. Corroborating the expressed suggestion, the highest lowering of the work was found to be for aluminum (4.8 to 5.6), less for zinc (1.5), and practically zero for bronze.

From the given table of the mentioned magnitudes it is seen that, all other conditions being equal, the specific cutting work is lowered as many times as h is increased. The torque of the drill remains almost constant.

Authors reason that if the lowering of the cutting work in the liquid medium occurs because of its lubricating action, then keeping the axial pressure on the drill constant, only the torque would have to diminish, as a consequence of diminishing forces of external friction; h would have to remain constant. On the basis of the investigation results, however, authors conclude that the lowering of the specific cutting work is caused basically not by the lubricating action of the medium but by its cutting action—easing of plastic deformation and destruction of the metal.

D. Mazkevich, USA

1287. Epifanov, G. I., Effect of mechanical properties of metals on the efficiency of action of liquid media at free planing (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **75, 3, 415–418, Nov. 1950.**

It has been shown earlier (see preceding review) that, in drilling, the maximum lowering of work under the action of active liquid media takes place in viscous, very plastic, highly hardenable metals. Author investigated the effect of butyl alcohol on free planing, using (1) aluminum, copper; (2) tin, zinc; (3)

bronze, cast iron, and antimony. Cutting speed was 10 cm/min. The HSS cutters had a cutting angle of 68°. The cutting depth was: for the aluminum, 0.2 mm; for the other metals, 0.3 mm.

The shrinkage of the chip (determined by $\eta = l_0/l$, where l_0 is length of the cut, l length of the obtained chip) was

	Aluminum	Copper	Tin	Zinc
Dry cutting	7.3	4.3	1.88	1.68
Cutting in butyl alcohol	2.8	2.7	1.65	1.60

(It is very difficult to determine the shrinkage of the chips of bronze, cast iron, and antimony, since the chip consists of separated small pieces of irregular form.) Author gives also the following table:

	Aluminum	Copper	Tin	Zinc	Bronze	Cast iron	Antimony
Hardness (kg/mm²)	26	46	8.3	52	105	303	53
Specific work, cutting dry (kgm/cm³)	90	130	11.4	46.5	62	62	1.8
same, cutting in butyl alcohol	29.5	67	8.0	42.5	62	64	1.4

To any shop man, columns 4, 5, and 6 do not tell anything new. But it would be interesting to obtain similar data for steel and stainless steel. D. Mazkevich, USA

1288. **Boehm, F., Production gain in rod drawing through continuous velocity regulation** (in German), *Stahl u. Eisen* **72,** 14, 797–804, July 1952.

Paper discusses loss of production due to inability to use full capacity of rod-drawing equipment over entire range of rod diameters if stepwise speed variation only is possible. At each gear setting there is a maximum rod diameter which can be reduced by a fixed amount, this diameter decreasing with increasing speed. For intermediate diameters, the lower speed must be used. Continuous speed variation overcomes this drawback and permits increased production. Time study of the process is considered, and determination of drawing forces and limitations on operation of the equipment which prescribes its maximum capacity. Specific cases are evaluated for 30- and 60-hp equipment, giving the percentage improvement for various conditions of operation. E. H. Lee, USA

1289. **Hilbert, H. L., Deep drawing of large sheet-metal parts** (in German), *ZVDI* **94,** 25, 817–823, Sept. 1952.

Paper is a concise review of all problems arising from deep drawing of large parts. These problems include shape of platine and of finished part, choice of material, properties of tools, lubrication, planning, costs. Important are the figures, all of which have a bearing to parts of motorcar bodies.

C. Zwikker, Holland

1290. **Spear, P., Robinson, I. R., and Wolfe, K. J. B., The influence of machining and grinding methods on the mechanical and physical condition of metal surfaces,** Symp. Proper. metall. Surf., Institute of Metals, London, 59–100, Nov. 1952.

Surface finishes obtained by drilling, turning, grinding, honing, and superfinishing were evaluated with the help of x-ray-hardness and surface-roughness tests. Drills used in these tests were made of one of four different HSS. Differences in manufacture of drills were considered in the test results. Grinding and polishing entailed a layer of austenite on the flute surface which caused the chips to stick and jam. Removal of this austenitic layer improved performance of drills.

Turning tests on mild steel, brass, and Dural were carried out with HSS, carbide, and aluminum-oxide tools. The greatest amount of deformation near the workpiece surface was caused by HSS tools cutting at lower cutting speeds (62 and 134 fpm), and considerably less deformation was found when machining with carbide tools at a cutting speed of $^5/_8$ fpm. A burnishing action was observed when using ceramic tools at light depth of cut. In the x-ray analysis of the machined surface, the effect of the different rake angles of the various tools used was not considered.

Finer feeds produced better finishes in turning brass. A "secondary texture"—the smearing, tearing, and deposition of stray metal superimposed on the "primary texture"—occurs almost always irrespective of the feed rate.

It was possible to obtain very good finishes on HSS tools by grinding with coarser grinding wheels and taking the last pass at slow feed. The austenite content of the surface material in HSS tools was less when grinding dry with light cuts than when grinding with heavier cuts using a coolant. Whether the austenite in the tool surface was produced by grinding or heat treatment, it invariably lowered the performance of the cutting tool.

A. O. Schmidt, USA

1291. **Leyensetter, W., Determination of surface finish in turning through measurement of chip weight** (in German), *ZVDI* **94,** 25, 825–828, Sept. 1952.

Numerous orthogonal cutting tests indicate that chip-thickness ratio and chip weight per unit length may be correlated with workpiece surface finish and tool wear.

Dimitri Kececioglu, USA

1292. **Lázárovits, L., Testing spindle alignment (coaxiality) in machine tools,** *Acta Techn. Hung.* **4,** 1/4, 123–133, 1952.

Paper deals with the testing of coaxiality on machine tools. It analyzes in detail the testing of "true running," and points out the connections existing between the peripheral distribution of the runout and the eccentricity and the deviation from true form. The paper published in Hungarian contains a critical evaluation of the known methods for checking coaxiality, while in the present digest a new method for testing coaxiality is presented.

From author's summary

1293. **Crawford, J. H., and Merchant, M. E., The influence of higher rake angles on performance in milling,** *Machinery, Lond.* **81,** 2069, 47–55, July 10, 1952.

Face and slab milling of mild steel with HSS cutters having rake angles from 0 to 50 deg were studied at cutting speeds between 70 and 500 fpm. With the larger rake angles, tool life was better at the higher cutting speed of 164 fpm than at lower speeds in face milling. The effect of cutting speed was different in slab milling, and best performance was obtained at 68 fpm. In general, surface finish was improved and less power required with cutters of high rake angle, but these cutters are more sensitive to abrasion and cannot be used on surfaces with scale or abrasive inclusion. A. O. Schmidt, USA

Hydraulics; Cavitation; Transport

(See also Rev. 1309)

1294. **Kirschmer, O., Critical considerations on the question of pipe friction** (in German), *ZVDI* **94,** 24, 785–791, Aug. 1952.

The results of the experiments of Nikuradse and the formulas of Prandtl and Colebrook-White are, at the present time, the most reliable basic data in the problem of pipe friction. These formulas are complicated, but they can be plotted as a family of curves for various values of the relative roughness on a diagram that can be used immediately in practical application. The theory of Prandtl, although not having yet reached its final expression, is

actually the most perfect attempt toward a theoretical explanation of flow mechanism.

Laboratory experiments on pipes of small diameter are more suitable for research on the laws of flow than experiments on industrial pipes, which are longer, more expensive, less precise, and of a more limited scope. Similitude considerations permit the establishment of the conditions that empirical formulas must fulfill and the limits of their application.

Reviewer cannot agree with author's opinions (1) that the value of the absolute roughness k has little effect on the resistance coefficient; if this is true for k varying from 3.3×10^{-5} to 1.2×10^{-1} and large diameters, as chosen by the author in his example (1 meter), it is not true for small diameters such as 0.1 or 0.2 m; (2) that it is possible, by experimenting on a small diameter, to find the true value of the absolute roughness of a pipe of large diameter and of the same material; the roughness of a material is, in fact, not constant and varies much from one fabrication to another (e.g., for steel pipes from 1 to 4).

Reviewer regrets also that author has not mentioned important experimental work on pipe friction, such as that of Schlichting (Göttingen) and Jorissen (Liège). Alb. Schlag, Belgium

1295. Benini, G., On the angle of best incidence of a diversion channel (in Italian), *Energia elett.* **29**, 6, 354–362, June 1952.

This is an introductory paper to a study of the problem of diversions from rivers, sponsored by the Association of Italian Electrical Industries. The problem is viewed both from the hydraulic standpoint and from the standpoint of the efficiency of the intake in limiting the amount of bed load transferred into the diversion channel. Author reviews and discusses the results obtained so far on the subject by a number of German, American, and Italian researchers. Because of the difficulty of making an exact analysis by taking into account all the factors involved, these results are almost exclusively experimental and qualitative; still, they give some interesting indications as to the hydraulic processes at the intake, the relations existing between angle of incidence, amount of liquid and solid discharge diverted, depth and mean velocity of water in the main channel, size distribution of bed load, and width of the intake. P. L. Romita, Italy

1296. Chien, N., The efficiency of depth-integrating suspended-sediment sampling, *Trans. Amer. geophys. Un.* **33**, 5, 693–698, Oct. 1952.

Because of the physical shape of the depth-integrating sampler, it is impossible to sample down to the bed. Only part of the total sediment load moving across the vertical will be caught by the sampler. Based on the suspended-load theory and bed-load function, this part of the total sediment load is analytically determined. The result is illustrated in graphical form, and its significance and possible errors are pointed out.

From author's summary

1297. McSkimin, H. J., Measurement of dynamic shear viscosity and stiffness of viscous liquids by means of traveling torsional waves, *J. acoust. Soc. Amer.* **24**, 4, 355–365, July 1952.

Measurements of the transverse wave-propagation properties of viscoelastic substances at ultrasonic frequencies have provided information on viscosity and stiffness at high shear rates. In addition to direct applications, this information is useful in the study of the molecular structure of high polymers. Author here describes apparatus and methods for measurements in the low ultrasonic frequency range. Many useful experimental details and data on several high-viscosity liquids are presented. Reviewer believes this paper to be a significant addition to the series on this general subject which has emanated from the Bell Telephone Laboratories. F. G. Blake, Jr., USA

1298. Brockett, G. F., Correlation of valve-sizing method, *Instruments* **25**, 6, 752–756, June 1952.

Article discusses the relative merits of current methods of valve sizing, and points out some pitfalls to be avoided.

From author's summary

1299. Kneisel, O., Selecting and sizing control valves, *Instruments* **25**, 7, 894–897, 918, 920, 922, 924, 926, July 1952.

Fifty-one factors to be considered for the selection of the proper control valve for a throttling application are briefly described. Three charts are given. From author's summary

1300. Krivoshein, N., Natural method of calculation of backwater curves (in Spanish), *Univ. nac. La Plata, Publ. Fac. Cienc. Fisicomat.* **4**, 4, 356–394, Dec. 1951.

Author proposes a calculation of backwater curves based on the existing relations between the simultaneous variations of the levels (height z) with discharges Q.

A preliminary work consists in the experimental determination of the characteristic curves indicating, in various sections, the values of the quotient r of Q and square root of the slope I, in function of z; these characteristic curves facilitate particularly the calculation of the backwater curves with the method of finite differences.

Different precisions concern the criteria of the approximation to be considered, the influence of the variation of flow, the tributaries, the kinetic energy of the flow, the critical slope.

Author indicates a logarithmic method of interpolation based on a parabolic variation of r in function of z, which is especially helpful when the available data are limited. He indicates, at the same time, the possibility of the extrapolation, emphasizing the case of the overflowed valleys.

In result, the method sets forth a basic study to clarify some important points existing in a classical fundamental problem.

L. Escande, France

Incompressible Flow: Laminar; Viscous

(See also Revs. 1348, 1355, 1356, 1430)

1301. Thom, A., and Klanfer, Laura, Designing a slot for a given wall velocity, *Aero. Res. Counc. Lond. curr. Pap.* no. 76, 6 pp., 6 figs., Dec. 1950, published 1952.

Paper gives numerical solution of pattern for incompressible fluid flowing at constant wall velocities on either side of a slot in a diverging channel. One ninth of a flow entering at velocity 2.718 is drawn off at the slot. The wall velocity and exit velocity for the remaining stream are unity. Solution was obtained by relaxation of difference equation approximating Laplace's equation.

W. Griffith, USA

1302. Payne, L. E., On axially symmetric flow and the method of generalized electrostatics, *Quart. appl. Math.* **10**, 3, 193–204, Oct. 1952.

Consider the steady potential flow of a perfect fluid about an axially symmetric body in n dimensions. Using a result of A. Weinstein [*Trans. Amer. math. Soc.* **63**, 342–354, 1948], author gives the formula

$$\psi\{n\} = Uy^{n-1}(n-1)^{-1}(1 - \varphi\{n+2\})$$

which expresses the steam function ψ in n dimensions in terms of an electrostatic potential φ for a body with the same meridian profile in $n+2$ dimensions (U is the free-stream velocity and y is the radial distance). Author has used this fact to find the stream function and virtual mass for flows about a spindle and a lens.

The solution for the spindle is new, while that for the lens has a much simpler form than the one given by Shiffman and Spencer [AMR 1, Rev. 123]. The virtual masses are found in terms of the capacity of the electrostatic problems.

Electrostatic potentials are listed for a single sphere, two separated spheres, prolate and oblate spheroids, and a disk. Applications to internal problems are also mentioned.

The method provides a neat and powerful way to obtain exact solutions to many interesting flow problems.

R. C. Roberts, USA

1303. **Nougaro, J., Graphical method for calculation of translation waves in open channels** (in French), *C. R. Acad. Sci. Paris* **235**, 5, 341–343, Aug. 1952.

Bergeron's method is modified assuming wave velocity = $(gH)^{1/2}$, where H is water height behind perturbation. Characteristics are no longer rectilinear, but problems can be solved using a technique well known in compressible-fluids dynamics or plasticity. G. Moretti, Argentina

1304. **Kampé de Fériet, J., and Kotik, J., On two-dimensional gravity waves of finite energy** (in French), *C. R. Acad. Sci. Paris* **235**, 3, 230–232, July 1952.

Authors give a new solution for two-dimensional gravity waves when the depth of the fluid is infinite. The free surface is supposed to be known (at the initial time) and the liquid is supposed to be delivered up without initial velocity. Solution satisfies the linearized equations of incompressible fluids and is valid in the field of Lebesgue's integrals. Total energy of these waves (in the whole two-dimensional field and per unit of thickness) is finite.

Giulio Supino, Italy

1305. **Toraldo di Francia, G., A variational principle for the computation of reflection coefficients,** *Phys. Rev.* **78**, p. 298, 1950.

Author considers the one-dimensional wave equation (i.e., the ordinary differential equation) $u'' + k^2u = 0$, where k is constant except across a potential barrier of finite width. He establishes a variational principle for the reflection coefficient. The principle can be used to determine the reflection coefficient (approximately) by means of approximate expressions for u. Two examples are given to test the method. A. Robinson, Canada

1306. **Fay, R. D., Waves in liquid-filled cylinders,** *J. acoust. Soc. Amer.* **24**, 5, 459–462, Sept. 1952.

Motivated by a desire to employ acoustic tube methods for measuring the acoustic impedances of materials in fluid media, author has studied the propagation of waves in liquid-filled cylinders. A rigorous analysis being tedious and difficult, the study was limited to axially symmetrical modes generated at single frequencies. Expressions are obtained for the phase velocities of free waves as a function of frequency times wall thickness.

The calculations were compared with observations on two pipes of the same outside diameter but different wall thicknesses. With no damping means applied to the tube, all measurements showed complex wave forms, indicating that more than one mode was excited, in reasonable agreement with the theory.

Author concludes that a practical apparatus for measuring underwater impedance could be constructed from a relatively thin-walled tube reinforced by any means which would not transmit vibrations in the axial direction. H. M. Trent, USA

1307. **Peters, A. S., Water waves over sloping beaches and the solution of a mixed boundary value problem for $\Delta^2\phi - k^2\phi = 0$ in a sector,** *Comm. pure appl. Math.* **5**, 1, 87–108, Feb. 1952.

By new methods, author proves mathematically the existence of small surface waves over a plane beach of arbitrary slope, which at large distance from the shore form an arbitrary angle with the shore line. Paper has mainly mathematical interest. Problem was solved simultaneously by different method by Roseau [AMR Rev. 2765]. H. Lundgren, Denmark

1308. **Kalinushkin, M. P., On the helical motion in conduits** (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 3, 359–366, Mar. 1952.

Series of experiments confirm author's thesis that a helical type of motion occurs rather commonly in circular conduits (presumably caused by local pressure gradients at inlets, bends, etc.). Main tools are a spherical pressure head with five openings for yaw measurements, and a suction tube for measurements of density of sawdust tracers (sensitive to tangential velocity component) across pipe diameter. The description and the control of the experiments seem to be insufficient for anything but rough qualitative conclusions; e.g., little attention is paid to upstream distribution of velocity and dust density, pressure gradients, presence of other secondary flows, etc.

M. V. Morkovin, USA

1309. **Giffen, E., Atomization of fuel sprays,** *Engineering* **174**, 4510, 6–10, July 1952.

Paper describes experiments on swirl atomizer sprays. Intermittent and continuous sprays were investigated at discharge velocities less than 80 ft/sec. Intermittent spray samples were obtained by impingement on magnesium oxide coated slides. In continuous tests, dye was added to liquid and spray was discharged horizontally over a series of troughs containing undyed liquid. Dye color intensity gave spray volume per trough. Comparison with impingement samples gave spray characteristics for each trough.

Results: Effect of increase in discharge velocity was to decrease mean droplet size and to increase proportion of small drops. Drop size decreased with increasing distance from nozzle—as would be expected, this effect was most pronounced at higher velocities. Viscosity and surface-tension tests were conducted using safety fuel, light lube oil, and water (viscosity range 15-fold, surface tension range 3-fold). Increase in viscosity caused not only an increase in mean drop size, but also a large increase in size of largest drops—this effect was most noticeable at low velocities. By comparison, effect of surface tension was barely noticeable. A. Shaffer, USA

1310. **Woods, L. C., The numerical solution of two-dimensional fluid motion in the neighborhood of stagnation points and sharp corners,** *Aero. Res. Counc. Lond. Rep. Mem.* 2726, 12 pp., Oct. 1949, published 1952.

In the computation of flow fields by means of the relaxation technique, the character of the singularities which arise at stagnation points or sharp corners ought to be taken into account. Paper derives the required formulas. G. Guderley, USA

1311. **Cassel, H. M., Capillary jump and capillary vortex in liquid flow along flat plates,** Proc. Sec. Midwest. Conf. Fluid Mech., Ohio State Univ. Press, 99–104, 1952. $6.

Author describes a radial laminar flow originating from a vertical liquid jet impinging on a horizontal flat plate. At a certain radius, a "capillary jump" is formed in which the layer of flow thickens and the liquid passes over a flattened vortex without the "back roll" characteristic of the usual hydraulic jump. Using average velocities and taking into account the effect of surface tension at the discontinuity, the momentum balance across the jump and the energy lost by friction in the inner laminar sheet

are used to derive an expression for the radial distance to the discontinuity. From experimental results which indicate that this distance varies directly as the 3/4 power of the flow rate, it is observed that the radius of the liquid surface at the beginning of the jump must be directly proportional to the depth of the laminar layer at this position in order to fit the data. However, the constant of proportionality depends on the liquid used.

Phillip Eisenberg, USA

1312. Tulin, M. P., Linearized incompressible laminar flows including unsteady flows, Proc. Sec. Midwest. Conf. Fluid Mech., Ohio State Univ. Press, 155–169, 1952. $6.

A linear second-order equation is obtained to yield approximate solutions of steady and unsteady laminar boundary-layer flow problems in two dimensions. Solutions of this equation are shown to be solutions of an appropriately linearized integral of the Prandtl boundary-layer equation of motion. Solutions in integral form are obtained for steady and unsteady flows of some generality, and particular interesting cases are studied in detail.

The class of steady flows studied by Falkner and Skan is treated in detail and a reasonable qualitative agreement is obtained. It is noted that Rayleigh's analogy solution for the steady flat plate flow is included among the solutions obtained. The linearized equation is considered well-suited for the qualitative study of unsteady boundary-layer flows in incompressible, two-dimensional flows. The unsteady flow involving an impulsive start from rest is studied in detail.

From author's summary by S. Ostrach, USA

1313. Nootbaar, R. F., and Kintner, R. C., Fluid friction in annuli of small clearance, Proc. Sec. Midwest. Conf. Fluid Mech., Ohio State Univ. Press, 185–194, 1952. $6.

The paper summarizes, in tabular form, the findings of previous experimenters and reports the results of new experimental data obtained on annuli of $D_2 = 0.375$ in. with D_1/D_2 ratios of 0.64, 0.72, 0.81, 0.91, using water and carboxy methyl cellulose solutions as fluids. Reynolds numbers were varied from 6 to 10,000.

From authors' summary

1314. DeLoach, B. C., and Millsaps, K., The relative stability of plane Poiseuille flow, Proc. Sec. Midwest. Conf. Fluid Mech., Ohio State Univ. Press, 201–206, 1952. $6.

The Galerkin method is used to calculate approximately the eigenvalues of symmetrical disturbance of plane Poiseuille flow. No new result is obtained. S. I. Pai, USA

Compressible Flow, Gas Dynamics

(See also Revs. 1337, 1339, 1340, 1342, 1356, 1359, 1360, 1363, 1364)

1315. Ehret, Dorris M., Accuracy of approximate methods for predicting pressures on pointed nonlifting bodies of revolution in supersonic flow, *NACA TN* 2764, 26 pp., Aug. 1952.

The accuracy of various methods for calculating the pressure in supersonic flow around pointed bodies of revolution at zero incidence is investigated. The results provided by the method of characteristics or, for the case of a straight cone, by the calculations of Taylor and Maccoll are taken as standards of comparison. Methods considered include linearized theory, a second-order theory, tangent-cone theories (in which the local pressure is taken to be equal to the pressure on a cone of equal slope), the theory of Eggers and Savin, and simple Newtonian impact theory. Calculations are made for cones, ogives, and an optimum body with modified (pointed) nose. It is concluded that none of the approximate methods mentioned is acceptable over the full range of the parameters involved, but that at least one of these methods is applicable in each case. Author stresses the differences between the times required for the application of the various methods, but it would appear that these depend largely on experience and the mechanical aids employed.

A. Robinson, Canada

1316. Van Dyke, M. D., Practical calculation of second-order supersonic flow past nonlifting bodies of revolution, *NACA TN* 2744, 62 pp., July 1952.

Calculation of the velocity and pressure distribution in supersonic flow over body of revolution at zero angle of attack is based on first obtaining solution to the linearized potential-flow equation. Second-order solution is then found by an iterative procedure using the first solution and a certain particular integral of the (linear) iterative equation. Use of approximate boundary conditions at surface of object is discussed in detail.

Procedure of numerically calculating flow past given body is given in detail, and author states that this can be applied without necessarily understanding details of the theory. Extensive tables and charts are included for this purpose.

M. Morduchow, USA

1317. Phythian, J. E., The energy distribution behind a decaying two-dimensional shock, *Quart. J. Mech. appl. Math.* 5, part 3, 318–323, Sept. 1952.

An accuracy hypothesis is formulated which leads to a check of Friedrich's theory [AMR **2**, Rev. 340] of the steady plane flow behind the shock wave attached to an infinitely long, thin, symmetrical body in a supersonic stream. The hypothesis is modeled upon that of Lighthill [AMR **4**, Rev. 2580], who examined Friedrich's theory for a decaying one-dimensional shock wave. The author modifies the work in order to examine the flow past a two-dimensional thin airfoil when there are two shocks forming an N-wave. There is a discussion of the energy flux far downstream.

D. C. Pack, England

1318. Kawamura, T., On the detached shock wave in front of a body of revolution moving with supersonic speeds, *J. phys. Soc. Japan* **7**, 5, 486–488, Sept./Oct. 1952.

Uniform supersonic flow past a body of revolution with a finite radius of curvature at its nose is studied. Various hydrodynamical quantities are expanded in power series of the coordinates in the neighborhood of the stagnation point of the body. The coefficients of the series are determined by the boundary conditions at the surface of the body as well as by the shock-wave conditions at the shock wave. Numerical results are compared with the existing experiments as well as with the theoretical results obtained previously by the writer. (From author's summary.)

Reviewer considers these calculations are not essentially different from works by Lim, et al., referenced in paper. Numerical results of distance from shock wave to body in terms of radius of curvature of the nose agree reasonably well with experiments. Theory also checks fairly well with author's previous calculations solving flow between shock and body by assuming incompressible potential flow with suitable boundary conditions.

H. G. Stever, USA

1319. Morkovin, M. V., Pierce, C. A., Jr., and Craven, C. E., Interaction of a side jet with a supersonic main stream, *Univ. Michigan, Engng. Res. Inst., Bull.* no. 35, 34 pp., Sept. 1952. $1.20.

Experiments were conducted on effects of supersonic jets (air or steam) issuing from straight or divergent nozzles placed in the

cylindrical surface of a cone-cylinder body which was set at 0° or 14° incidence in a uniform air stream of Mach number 1.9. The pressure ratio across the side nozzle was used as independent parameter and varied from 0 to about 50. The experiments included schlieren and shadow photography, boundary-layer visualization, and pressure measurements on the body surface. The jet bent rapidly downstream with violent mixing, causing regions of both high and low pressures on the body. The "additional" force components and coefficients due to the side jet were determined. N. H. Johannesen, England

1320. **Wu, C.-H., Brown, C. A., and Prian, V. D., An approximate method of determining the subsonic flow in an arbitrary stream filament of revolution cut by arbitrary turbomachine blades,** *NACA TN* 2702, 46 pp., June 1952.

A method is presented to obtain a relatively quick approximate determination of the detailed subsonic flow of a nonviscous fluid past arbitrary turbomachine blades. The method is illustrated with examples of compressible flow in a turbine cascade and in a centrifugal compressor. For these high-solidity blades, three terms of the Taylor series are found to give sufficient accuracy. Sufficient convergence is obtained in the turbine cascade after two cycles of computation and in the centrifugal compressor after four cycles of computation. The detailed flow variation obtained compares very well with an available numerical solution and experimental data for the turbine cascade, and with detailed experimental measurements for the centrifugal compressor. J. F. Manildi, USA

1321. **Legendre, R., Eichelbrenner, E. A., and v. Baranoff, A., Transonic flow around highly sweptback wings** (in French), *ONERA Publ.* no. 53, 54 pp., 1952.

Paper presents the results of five successive studies of the theoretical lifting characteristics of highly swept wings and wing-body combinations. The analysis consists, essentially, of an extension of the slender-wing theory originated by R. T. Jones [AMR **2**, Rev. 902] to cases in which the trailing edges, as well as the leading edges, are swept back. The entire investigation is based on the equations of linearized compressible-flow theory rather than on the nonlinear equation generally associated with transonic flow.

The basic theory is furnished in the first part of the paper. The second part concerns the clarification of a number of mathematical questions that arise in the analysis. The third part describes and gives the results of numerical calculations for a family of swept wings having planforms bounded by straight lines. The fourth part describes an electrical analog for the rapid determination of the pressure distribution. The fifth part of the paper is concerned with the influence of the fuselage. The analysis in this section does not follow the pattern established in the preceding parts but may be considered more as an extension of the work of Ward [AMR **3**, Rev. 529]. As in the remainder of the paper, the emphasis is on the extension of existing theory to cases having wings with sweptback trailing edges. In contrast to the result of Ward, that the lift of a wing-body combination having a wing with a straight trailing edge is less than that of the wing alone, present results indicate that the lift of a combination having a wing with sweptback trailing edges may be greater than that of the wing alone. J. R. Spreiter, USA

1322. **Greidanus, J. H., Physical interpretation of the characteristics of transonic and supersonic flows** (in Dutch), *Ingenieur* **64, 38,** L.29–L.35, Sept. 1952.

Steady compressible flow is analyzed in terms of one-dimensional piston flow. Thus, the principal properties of two-dimensional supersonic flow are derived in an elementary and instructive way. Purpose of paper being didactic, it seems remarkable that the simplicity of the formulas involved is spoiled by not using rational units of force, mass, and energy.

S. B. Berndt, Sweden

1323. **Chapman, D. R., Airfoil profiles for minimum pressure drag at supersonic velocities—application of shock-expansion theory, including consideration of hypersonic range,** *NACA TN* 2787, 44 pp., Sept. 1952.

Two-dimensional airfoil profiles of minimum pressure drag for various structural criteria have been determined on the basis of shock expansion theory for the Mach number range 1.5 to ∞. The value of the base pressure used has a significant effect at low supersonic speeds. It is found (as previously shown by Klunker and Harder, see AMR **5**, Rev. 3152) that linearized theory is satisfactory for determining the shape of minimum drag airfoils.

Keith C. Harder, USA

1324. **Chapman, D. R., Airfoil profiles for minimum pressure drag at supersonic velocities—general analysis with application to linearized supersonic flow,** *NACA Rep.* 1063, 14 pp., 1952.

Supersedes *TN* 2264, reviewed in AMR **4**, Rev. 1668. Various examples of optimum profiles given in *TN* 2264 have been supplemented and revised in accordance with experimental measurements of base pressure published subsequent to *TN* 2264. Ed.

1325. **Fuller, F. E., Computation of Possio's integral for linearized supersonic flow,** *J. aero. Sci.* **19,** 9, 640–642, Sept. 1952.

A calculation method suitable for digital computing machines is formulated for Possio's integral, giving pressure and flutter aerodynamic coefficients for suitable wing planforms. One machine setup applies to all Mach numbers and frequencies for a particular planform. S. A. Schaaf, USA

1326. **Siestrunck, R., and Fabri, J., Linearized solution of a vortical motion of a compressible fluid in an axial wheel** (in French), *Actes Coll. inter. Mécan.* **I,** *Publ. sci. tech. Min. Air, Paris,* no. 248, 75–82, 1951.

Consider the flow in an axial rotor, limited by a cylindrical external wall. Rotor consists of a large number of blades replaced by radial lifting-line segments. Flow is rotational symmetric; stream function satisfies an equation obtained by expressing relation between enthalpy gradient and vorticity. In passage through rotor disk, stream function and radial velocity component are continuous. Two main velocities are introduced, m in axial direction, M velocity of rotor tips. Equations are linearized by neglecting m^3 and assuming that disturbance velocities as compared with flow before disk are also of order m^3.

Some examples are given, where solutions assume very simple forms, as potential flow behind rotor and flow; where, in infinity behind rotor, tangential vorticity component vanishes. Here fluid rotates in infinity with same angular velocity as rotor.

Finally, it is remarked that results of incompressible case can sometimes be applied directly, the continuity conditions on the disk being the same in the approximation involved.

R. Timman, Holland

1327. **Martin, J. C., and Jeffreys, Isabella, Span load distributions resulting from angle of attack, rolling, and pitching for tapered sweptback wings with streamwise tips. Supersonic leading and trailing edges,** *NACA TN* 2643, 143 pp., July 1952.

On the basis of the linearized supersonic-flow theory, the span-load distributions resulting from constant angle of attack, from steady rolling, and from steady pitching were calculated for a

series of thin sweptback tapered wings with streamwise tips and with supersonic leading and trailing edges. The results are valid for the Mach number range for which the Mach line from either wing tip does not intersect the remote half wing. The results of the analysis are presented as a series of design charts. Some illustrative variations of the spanwise distributions of circulation with the various design parameters are also presented.

From authors' summary by G. R. Graetzer, USA

1328. Behrbohm, H., The flat triangular wing with subsonic leading edges in steady pitch and roll at supersonic velocities, *SAAB Aircr. Co., Linköping, TN* 9, 22 pp., 1952.

Paper presents the procedure for determining the potential of the disturbance velocity on the wing due to a local angle of attack distributed linearly (can be generalized to polynomial distribution), longitudinally, or laterally.

Method is unique in that the upwash ahead of the wing is determined which defines a constant needed in the potential of the disturbance velocity. Supersonic source singularities are distributed in the wing reference plane along radial lines from the apex, with strengths depending on the inclination of the ray with the axis of symmetry. Integrating over all the radial lines gives a general solution of the linear potential equation which, after satisfying boundary conditions, leads to the integral equation for a certain function of the normal component of the disturbance velocity (upwash), and a constant. From the solution of the integral equation for the upwash, the constant is obtained when the upwash at the Mach cone is zero.

In conclusion, the potentials of the disturbance velocity are derived (pitch and roll); however, the derivation of the stability derivative is left to the reader, who is referred to the references.

John DeYoung, USA

1329. Adams, M. C., and Sears, W. R., On an extension of slender-wing theory, *J. aero. Sci.* **19,** 6, 424–425, June 1952.

Operational approach to slender-body theory is taken one stage further by retaining next terms in series expansions of Bessel functions. Detailed applications of results are to be published ater.

G. N. Ward, England

1330. Graham, E. W., Notes on the drag of scoops and blunt bodies, *Douglas Aircr. Co., Rep.* SM-13747, 18 pp., Apr. 1950.

Suction force acting on leading edge of air scoop with detached shock wave at supersonic speeds is evaluated on the assumption that the flow past the scoop can be adequately represented by a duct in a choked channel. The assumptions, as author admits, are more radical than those made by reviewer [see AMR **4,** Rev. 2406], which were by no means conservative themselves. Since the suction force is just the difference between the drags on the stagnation streamline obtained by applying the momentum balance alternately to the external and the internal flow, and since the former was obtained in *NACA TN* 1921, the need for further simplifying assumptions is not evident. Reviewer notes, also, that additive drag plus suction force is equal to the average of stagnation-streamline drags calculated from external and internal momentum balances. Consequently, this combined force is much less sensitive to the accuracy of the assumptions concerning the external flow than the suction force itself.

W. E. Moeckel, USA

1331. Miles, J. W., On the Kirchhoff solution for an oscillating wing in subsonic compressible flow, *J. aero. Sci.* **19,** 11, p. 785 Nov. 1952.

1332. Dorrance, W. H., Two-dimensional airfoils at moderate hypersonic velocities, *J. aero. Sci.* **19,** 9, 593–600, Sept. 1952.

The pressure coefficient on a two-dimensional airfoil in hypersonic flow is approximated by developing the Prandtl-Meyer and Rankine-Hugoniot relations in powers of the hypersonic similarity parameter $K = M_0\delta$, where M_0 is the free-stream Mach number and δ is the airfoil thickness ratio. For M_0 greater than 3.2, three terms in these series are shown to represent the pressure coefficient and to agree with each other over a wide range of airfoil profiles, angles of attack, and thickness ratios with engineering accuracy. By making use of the approximations described above, analytic formulas for the lift-moment and drag coefficients are calculated for a large variety of airfoil profiles.

Theoretical predictions of the lift-moment and drag coefficients for a 5% thick double wedge airfoil at $M_0 = 6.9$ are shown to be in agreement with wind-tunnel test data.

H. R. Lawrence, USA

1333. Mangler, K. W., Improper integrals in theoretical aerodynamics, *Aero. Res. Counc. Lond. curr. Pap.* **94,** 34 pp., 1 fig., June 1951, published 1952.

Rules are derived for the evaluation of the principal value or the "finite part" (Hadamard) of a family of improper integrals occurring in potential theory. Also, rules for the differentiation and integration by parts of these improper integrals are derived. A theorem is given for the integration of functions which involve principal values of higher order. The results are useful in the linearized potential theory of supersonic flows, and, in particular, for the theory of thin wings in a supersonic flow.

H. G. Loos, USA

1334. Klyatchkin, A. L., Limit state of one-dimensional flow of a viscous gas with mechanical action in a cylindrical pipe (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **84,** 2, 241–244, May 1952.

Using basic equations of continuity, momentum, and energy, author discusses the limit state of one-dimensional compressible flow in a pipe. It is found that for flows with both friction and mechanical action, the transition through sonic velocity approaches an isentropic process. For polytropic flows with mechanical action, continuous change through sonic velocity is found possible.

Author's basic equations appear to be in error [see, for example, *J. appl. Mech.* **14,** 4, 317–336, Dec. 1947]. His conclusions, however, are correct.

T. Y. Toong, USA

1335. Elder, F. K., Jr., and de Haas, N., Experimental study of the formation of a vortex ring at the open end of a cylindrical shock tube, *J. appl. Phys.* **23,** 10, 1065–1069, Oct. 1952.

Interesting schlieren photographs are presented of the flow at the open end of a shock tube, which show the emergent shock wave, the vortex ring, and associated flow for two weak shock waves. Authors combine the photographs to plot an (x, t)-plane with the origin at the tube orifice. A plot of the growth of the vortex diameter with time is also given.

Reviewer believes that it is very important to study the flow phenomena (shock waves) going back into the tube for subsonic and supersonic flows behind the emergent shock wave before a quantitative analysis can be formulated for this type of flow.

G. N. Patterson, Canada

1336. Ludford, G. S. S., On an extension of Riemann's method of integration, with applications to one-dimensional gas dynamics, *Proc. Camb. phil. Soc.* **49,** part 3, 499–510, July 1952.

The initial value problem for one-dimensional isentropic un-

steady motion of a perfect gas may be formulated as a Cauchy problem for a linear hyperbolic partial differential equation [Courant and Friedrichs, AMR 1, Rev. 1661]. This paper investigates flows whose initial values ($u = u(x)$, $a = a(x)$ at $t = 0$) are such that the initial curve for the Cauchy problem is tangential at some point to a characteristic. Although such a Cauchy problem has no continuous single-valued solution, author succeeds in defining a physically meaningful, multiple-valued solution, and obtains a neat integral representation for it. This not only resolves a difficulty in the classical treatment of the initial value problem, but also simplifies consideration of the flow problem. For flow in an infinite tube, it is shown that initial data of the above sort guarantee the occurrence of a limit line (and hence eventual breakdown of the flow); for flow in a closed tube, it is shown that, no matter what (nonconstant) initial data are prescribed, the flow will break down.

Courtesy of Mathematical Reviews J. B. Serrin, USA

Turbulence, Boundary Layer, etc.

(See also Revs. 1312, 1354, 1376, 1435)

1337. Weske, J. R., General theory of boundary layer intakes, Proc. Sec. Midwest. Conf. Fluid Mech., Ohio State Univ. Press, 207–218, 1952. $6.

Paper treats the characteristics of boundary-layer intake diffusors for incompressible turbulent layers. Calculated curves of displacement and momentum thickness in an unfavorable pressure gradient are given, but it is not clear how these were attained or to what intake configuration they apply. Author states that details of the method of calculation will be given in a separate paper. Envelopes of diffusor efficiencies are given as functions of ratio of boundary-layer thickness to diffusor opening, of mass flow, and of pressure increase between diffusor opening and undisturbed flow. A. M. Kuethe, USA

1338. Jansen, L., On heat transfer at laminar flow between two parallel plates (in German), *Schweiz. Bauztg.* **70,** 37, 535–536, Sept. 1952.

Paper treats problem of fully developed Poiseuille flow between two parallel plates. The boundary condition imposed is one of constant heat flux. The temperature field is found for two cases—two heated plates; with one plate heated, the other insulated. The respective Nusselt numbers are found to be: $Nu = 4.12$, and $Nu = 2.70$. B. W. Augenstein, USA

1339. Moore, L. L., A solution of the laminar boundary layer equations for a compressible fluid with variable properties, including dissociation, *J. aero. Sci.* **19,** 8, 505–518, Aug. 1952.

Author solves the problem of the laminar boundary layer for the insulated flat plate without radiation and for the plate with heat transfer covering a range of Mach numbers between 1 and 20. He reduces the nonlinear partial differential equations to a system of five ordinary differential equations which are solved with the differential analyzer at the University of California. A careful selection of the experimental and theoretical values for the physical properties of the dimensionless parameters and their changes due to the dissociation of the air at high temperatures has been compiled from the presently available data. Graphs of the equilibrium decomposition of air at pressure from 0.0001 to 1.0 atmosphere of the variation of the specific enthalpy and of the Prandtl number and absolute viscosity of air are given as functions of temperature. Assuming an ambient temperature of 400 R, the results of the mechanical integration show how the dissociation of the air affects the local skin friction and the heat-transfer coefficients. Comparing these values with those of other authors who made calculations without dissociation, one sees that dissociation has nearly no influence on skin friction and heat transfer between 400 and 2500 R; however, for temperature above 2500 R, it causes a decrease in the insulated plate temperature, and the dissociation for higher values of the enthalpy changes the heat transfer to an even greater extent.

K. Pohlhausen, USA

1340. Morduchow, M., On heat transfer over a sweat-cooled surface in laminar compressible flow with a pressure gradient, *J. aero. Sci.* **19,** 10, 705–712, Oct. 1952.

An approximate method is given for rapid calculation of effect of sweat-cooling in two-dimensional boundary layers in compressible laminar flow. This is of interest in connection with cooling of blades of turbomachines and of surface of aircraft at high-speed flight at high altitudes. Calculations are based on a modified Kármán-Pohlhausen method with the following assumptions: (1) Constant wall temperature; (2) heat transfer to wall entirely absorbed by injected coolant; (3) ratio of dynamical to thermal boundary-layer constant; (4) Prandtl number equals unity; (5) viscosity and heat conductivity proportional to absolute temperature. Heat transfer, skin friction, and injection velocity necessary to maintain constant wall temperature are obtained, and thereby simple integrals only need be evaluated. Results of numerical calculations are presented for flow near forward stagnation point and for flow over a turbine blade.

H. Schuh, Sweden

1341. Truckenbrodt, E., A quadrature method for calculation of the laminar and turbulent boundary layer for plane and rotationally symmetric flow (in German), *Ing.-Arch.* **20,** 4, 211–228, 1952.

An approximate procedure is developed which permits calculation, on a uniform basis, of laminar and turbulent boundary layers in two-dimensional or rotationally symmetrical incompressible flow. It makes use of von Kármán's momentum equation and an analogous integrated energy equation as introduced by K. Wieghardt. Both constitute simultaneous differential equations for the momentum thickness δ and the form parameter H (ratio of displacement to momentum thickness) of the boundary layer. Other parameters (wall shearing stress, dissipation energy, energy thickness of boundary layer) appearing in these equations are expressed as functions of δ and H with the use of Hartree's velocity profiles for laminar flow, and from measurements by K. Wieghardt, H. Ludwieg, W. Tillman, and J. Rotta for turbulent flow. With some simplifying assumptions, the momentum thickness δ and the form parameter H are obtained by two simple integrations. The method is applied to calculate the laminar boundary layer in a linearly decelerating flow for which an exact solution by L. Howarth is available, and the turbulent boundary layer on an airfoil profile NACA 65(216)–222. The momentum thickness and the separation point of the laminar boundary layer agree considerably better with the exact calculation than the usual solution obtained from the momentum equation. For the turbulent boundary layer also, good agreement of the momentum thickness except near the separation point and of the shape parameter with measured values is obtained. E. R. G. Eckert, USA

1342. Maslen, S. H., Second approximation to laminar compressible boundary layer on flat plate in slip flow, *NACA TN* 2818, 38 pp., Nov. 1952.

First-order solution for constant wall temperature is given. Effect of slip at wall as well as interaction between boundary-layer flow and outer stream flow are taken into consideration.

Solution is obtained explicitly in terms of known zero-order, or continuum solution. No assumptions regarding Prandtl number or viscosity-temperature law need be made. First-order solution gives a decrease in heat transfer and, for supersonic flow, an increase in skin friction. For subsonic flow, there is no first-order shear effect. Change in heat transfer is due to slip and change in friction is due to interaction of zero- and first-order velocities at outer edge of boundary layer.

From author's summary by H. Görtler, Germany

1343. Tifford, A. N., and Chu, S. T., Heat transfer in laminar boundary layers subject to surface pressure and temperature distributions, Proc. Sec. Midwest. Conf. Fluid Mech., Ohio State Univ. Press, 363–377, 1952. $6.

Author presents computer solutions for the thermal boundary-layer equations for "wedge flow" with power-function free-stream velocity and wall-temperature variation.

Concerning the effect of pressure gradient on the variation of Nusselt number with Prandtl number, results indicate that at very large Pr, Nu increases as $Pr^{1/2}$ regardless of the surface pressure gradient, except at a separation point; that in the latter case it increases as $Pr^{1/4}$; and that at very small Pr, Nu increases as $Pr^{1/2}$ under all surface-pressure-gradient conditions.

In the case of the insulated surface, it is found that the recovery factor is unaffected by pressure gradient and depends on $Pr^{1/2}$, as in the flat plate case.

Paper should be compared with that of S. Levy [see AMR **6**, Rev. 219], who treats the same problem.

L. M. Grossman, Holland

1344. Munk, M. M., On the mechanism of turbulent fluid motion, Proc. Sec. Midwest. Conf. Fluid Mech., Ohio State Univ. Press, 19–33, 1952. $6.

A general qualitative picture of turbulent motion is given by describing the merging and decay of vortex rings [see also AMR **4**, Rev. 4548]. But all these ideas are not condensed into a mathematical formulation. K. Wieghardt, Germany

1345. Ribner, H. S., and Tucker, M., Turbulence in a contracting stream, Proc. Sec. Midwest. Conf. Fluid Mech., Ohio State Univ. Press, 57–66, 1952. $6.

Shortened form of AMR **5**, Rev. 2432.

W. D. Baines, Canada

1346. Kampé de Fériet, J., Introduction to the statistical theory of turbulence correlation and spectrum (Lecture series no. 8, prepared by S. I. Pai), Univ. Maryland, Inst. Fluid Dynamics appl. Math., 162 pp., 1950–1951.

The main purpose of this series of lectures is to discuss the mathematical relationship between the correlation tensor and the spectral tensor in homogeneous turbulence. In the first half of the series, using time averages, space averages, and space-time averages, author, with the help of a modification of Wiener's harmonic analysis, defines the relationship as a Fourier-Stieltjes transform. If we have a velocity vector field $u_j(t)$ as a function of time, when the correlation tensor $\rho_{j,k}(h)$ and the spectral tensor $S_{j,k}(\lambda)$ are connected by $\rho_{j,k}(h) = \int_{-\infty}^{\infty} e^{i\lambda h} dS_{j,k}(\lambda)$ $j, k, = 1, 2, 3$, when each $u_j(t)$ is complex valued and belongs to L^2 and, thus, to L in each finite interval. The relationship is first defined for truncated functions and then is shown to exist in the limit as the above. The off-diagonal terms are complex-valued functions of bounded variation, while the diagonal terms are real nondecreasing functions of λ. A similar result holds for the harmonic analysis of a velocity vector field relative to three-dimensional space at a given time, and for the velocity vector field as a function of space and time.

The second half deals with the harmonic analysis of a set of random functions stationary on an Abelian group. A probability system is defined in the usual way as (Ω, S, μ), an Abelian group G, and a real valued function $F(\alpha, \omega)$ defined on $G \times \Omega$ which is measurable in ω for every $\alpha \epsilon G$, if for every $E \epsilon S$ Prob$[\omega \epsilon E] = \mu(E)$. If a representation G' of G in the group of one-to-one measure-preserving transformations of Ω into itself is then defined, we have $F(\alpha, \omega) = f(T_x\omega)$. A random vector field $u_j(x, \omega)$ representing the velocity of a spatially homogeneous turbulence is then equal to $f_j(T_x\omega)$, where T_x is an element of the Abelian group of translations in Euclidean three space. If $f(T_x\omega) \epsilon L^2(\Omega)$, then $f(T_x\omega) = U_x f(\omega)$, where U_x is a unitary operator. Then, to every weakly continuous group of unitary transformations there corresponds a family of projections such that $(U_x f, g) = \int_{\Lambda} e^{i\lambda x} d(E_\lambda f, g)$, where Λ is the space composed of λ: $\lambda_1, \lambda_2, \lambda_3$. The spectral tensor is the equal to $(E_\lambda f_j, f_k)$, and we have for a statistically continuous random vector field $\rho_{j,k}(h) = \int_{\Lambda} e^{i\lambda h} dS_{j,k}(\lambda)$, $j, k = 1, 2, 3$.

Such a representation is fruitful in the kinematics of homogeneous turbulence, but for the dynamics, where the problem of the evaluation of the spectrum has to be considered, there is no theoretical foundation in statistical mechanics, as in the above, to guide the investigator. Robert Simon, USA

1347. Van Le, N., The von Kármán integral method as applied to a turbulent boundary layer, *J. aero. Sci.* **19,** 9, 647–648, Sept. 1952.

Considering the momentum change across a control volume, author rederives the momentum equation, previously given by Bidwell [AMR **5**, Rev. 2445], for two-dimensional incompressible turbulent boundary layer, including the mean fluctuation terms.

S. F. Shen, USA

1348. Ness, N., On the temperature distribution along a semi-infinite sweat-cooled plate, *J. aero. Sci.* **19,** 11, 760–768, Nov. 1952.

The longitudinal temperature distribution T_x along the outer surface of a laterally infinite, thin porous plate is determined under operating conditions of a high-temperature incompressible and laminar gas stream g flowing longitudinally along the outer surface, and uniform cooling-gas g injection from the inner surface through the plate. This is an extension of the idealized case (Yuan) where longitudinal heat conduction in the plate is neglected. A solution to the present problem is effected by assuming constant gas and thermal properties, fourth-degree polynomial boundary-layer velocity and temperature profiles, and the familiar Weinbaum and Wheeler results of equal wall and cooling-gas temperature.

Solution of the thermal and usual Prandtl boundary-layer equations results in a finite temperature gradient at the plate leading edge, as contrasted to an infinite gradient when longitudinal conduction is neglected. For the particular leading-edge boundary condition of equal wall and free-stream temperature, author finds that, with Prandtl numbers greater than 0.35, the ratio of thermal to velocity boundary-layer thickness δ_t/δ_v is less than unity in the range $0 \leq x < \infty$, and equal to unity as $x \to \infty$. As expected, the wall temperature approaches the coolant temperature as $x \to \infty$, regardless of longitudinal conduction. The over-all results suggest a higher wall temperature and lower boundary-layer-thickness ratio δ_t/δ_v when longitudinal wall conduction is not neglected.

Reviewer feels that paper represents a valuable contribution to the literature on sweat cooling. P. J. Schneider, USA

Aerodynamics of Flight; Wind Forces

(See also Revs. 1183, 1321, 1327, 1328)

1349. **Sissingh, G. J., Comparison of helicopter rotor model tests of aerodynamic damping with theoretical estimates,** *Aero. Res. Counc. Lond. curr. Pap.* 98, 12 pp., 4 figs., Aug. 1951, published 1952.

The longitudinal tilting, i.e., flapping, oscillations of the tip-path plane of the blades coupled with the pitching or rolling oscillations of the rotor are considered. The "quasi-static" simplification of the flapping equation is used as well as the complete equations. Calculations are carried out both for the free oscillations and for the forced oscillations of the tip-path plane due to a given pitching oscillation of the rotor. Comparison between results of the calculations and of tests previously performed (especially *RAE T.N.* no. Aero 2049, 1950) indicates, on the whole, satisfactory agreement between theory and experiment. The important parameter here is $p = \nu/\Omega K$, where ν is frequency of the rotor pitching, Ω angular rotor speed, and K specific aerodynamic damping of a rotor blade, proportional to the inertia number γ. It is shown that for ordinary full-scale flight, p is sufficiently small so that the quasi-static analysis gives accurate results, while for most model tests, p is much larger and the complete equations of motion must then be used.

Morris Morduchow, USA

1350. **Souter, R. K., and Emerson, J. B., Summary of available hail literature and the effect of hail on aircraft in flight,** *NACA TN* 2734, 162 pp., Sept. 1952.

1351. **Mattioli, E., Hooke's gas in aerothermodynamics,** *J. aero. Sci.* **19,** 9, 642–643, Sept. 1952.

It is shown that the use of Hooke's gas ($\gamma = -1$) is inopportune, and that it is preferable to limit oneself to von Kármán-Tsien's "tangent gas." One observes that the "correction coefficient" of the latter is nearly exact in the entire flow if $M_{max} = \sim 0.5$. From author's summary

1352. **Merten, K. F., and Stephenson, B. H., Some dynamic effects of fuel motion in simplified model tip tanks on suddenly excited bending oscillations,** *NACA TN* 2789, 35 pp., Sept. 1952.

The results of investigation indicate that, after several cycles, substantial damping may be obtained from fuel sloshing in a tip tank, and the effective mass of the fuel may vary considerably under certain conditions of tank oscillation. For the fluids tested, no effects attributable to viscosity were observed; but for a given beam-tank system, the density of fluid and tank fullness were found to be important parameters. From authors' summary

Aeroelasticity (Flutter, Divergence, etc.)

(See also Revs. 1221, 1325)

1353. **van de Vooren, A. I., and Bergh, H., Experimental determination of the aerodynamic coefficients of an oscillating wing in compressible, two-dimensional flow. Part II. Wing with oscillating axis of rotation,** *Nat. LuchtLab. Amsterdam Rap.* F.102, 7 pp., 14 figs., Feb. 1952.

Paper describes experiments designed to extend the results of part I of the same study [see AMR **6,** Rev. 533]. The test setup of part I was modified to permit the axis to perform a vertical harmonic motion. The mean angle of attack has been kept at zero.

These experiments supply sufficient information to make possible the calculation of k_b and m_a individually. The results indicate satisfactory agreement with theory.

Morton Alperin, USA

1354. **van de Vooren, A. I., and Bergh, H., Spontaneous oscillations of an aerofoil due to instability of the laminar boundary layer,** *Nat. LuchtLab. Amsterdam Rap.* F.96, 5 pp., 1951.

Authors observed small amplitude oscillations of an airfoil model in a wind tunnel. The oscillation frequencies coincided with the natural frequencies of the elastic suspension. The phenomena are explained as instability of the laminar boundary layer, using Lin's theory of stability limits. A criterion of stability is formulated. The oscillations disappear when air stream is made turbulent artificially. L. S. Dzung, Switzerland

1355. **Lambourne, N. C., On the conditions under which energy can be extracted from an air stream by an oscillating aerofoil,** *Aero. Quart.* **4,** 1, 54–68, Aug. 1952.

Author considers two-dimensional airfoil undergoing coupled bending-torsion oscillations in incompressible flow. Conditions on amplitude ratio and phase difference are sought which enable the airfoil to extract energy from the air stream at any speed. Analysis follows suggestions of Küssner [*NACA TM* 782]. Vortex-sheet theory shows that energy may be extracted for *all* values of frequency parameter; use of constant derivatives places upper limit on frequency parameter. Author shows that, under certain conditions, pure torsional flutter may occur during still-air resonance test. Results agree with Biot and Arnold [AMR **5,** Rev. 886] and form an interesting supplement to that work.

H. N. Abramson, USA

1356. **Chang, C.-C., On Theodorsen function in incompressible flow and *C*-function in supersonic flow,** *J. aero. Sci.* **19,** 10, 717–718, Oct. 1952.

Author discusses briefly the physical aspect of extending the Theodorsen function to stable oscillations of an airfoil [see AMR **5,** Revs. 2700–2703], pointing out that the amplitude of the wake vortex strength must be small to satisfy the original assumption of Theodorsen. It is impossible physically that vorticity produced by the airfoil a long time ago should still maintain its strength. In fact, there will be some dissipation due to vorticity.

In supersonic flow, the corresponding Wagner function is the C function. The supersonic wake has no influence on the aerodynamic behavior of the airfoil, and thus the vorticity dissipation can be neglected. The aerodynamic load obtained from the C function is valid for both stable and unstable oscillations.

A. W. Babister, Scotland

Propellers, Fans, Turbines, Pumps, etc.

(See also Revs. 1320, 1326, 1367, 1381, 1391)

1357. **Bollier, H., The gain obtainable from regenerative feed heating,** *Escher Wyss News,* 23/24, 29–39, 1950/1951.

A graphical solution for calculating the gain obtainable from regenerative feed-water heating in a steam-turbine power plant. Author bases his calculations on the data obtained at the 50,000-kw Monceau Power Station operating at 90-atm abs pressure and 520-C steam temperature. Article includes short treatments on effects of feed pumps, steam ejectors, and drain coolers.

Many good and detailed treatments on this subject are already available in the steam-engineering literature. One of the most complete treatments in regenerative feed-water heating is that of J. Kenneth Salisbury [*ASME Trans.* **64,** April 1942, pp. 231–245]. S. Eskinazi, USA

1358. Margarit, G., On the fluid flow in hydraulic machines (in French), *Bull. tech. Suisse Rom.* **78**, 18, 233–235, Sept. 1952.

Author examines flow of ideal fluid within impeller by means of a relative flow function ψ such that $w_r = \partial\psi/r\partial\theta$, $w_t = -\partial\psi/\partial r$, and finds $\psi = \psi_0 - \omega r^2/2$, where ψ_0 is flow function corresponding to a potential function ϕ_0. He deduces energy at any point within impeller $E = uc_t/g +$ const. He states that flow lines around any obstacle with circulation may easily be drawn by adding a potential flow to the flow $\psi = -\omega r^2/2$.

Reviewer considers that paper adds little to present knowledge of flow in impellers, and notes that energy expression is equally well deduced from modified Bernoulli equation for flow within impeller, namely, $z + p/\gamma + w^2/2g = u^2/2g +$ const.

Alan Burn, Australia

1359. Rand, F. F., Jr., The shock ignition engine, *Aero. Engng. Rev.* **11**, 10, 22–27, 62, Oct. 1952.

Purpose of the article is to stimulate interest in research that will lead to a successful ramjet with combustion ignited and stabilized by a normal shock wave in the diffuser. Author bases many of his opinions upon the shock-tube experiments at the universities of Toronto and Michigan and at Sheffield, England, under W. C. F. Sheppard.

The idea has been proposed before, and paper offers only a rather vague and oversimplified general discussion. No experimental data are included to support the suppositions, nor is a rigorous analysis included. Ray E. Bolz, USA

1360. Wu, C.-H., A general theory of three-dimensional flow in subsonic and supersonic turbomachines of axial, radial, and mixed-flow types, *Trans. ASME* **74**, 8, 1363–1380, Nov. 1952.

See AMR **5**, Rev. 2893.

Flow and Flight Test Techniques

(See also Revs. 1297, 1370)

1361. Drougge, G., Some measurements at low supersonic speeds by a method for continuous variation of the Mach number, *Flygtekn. Försöksanst. Medd.*, 42, 16 pp., 1952.

Method described in AMR **3**, Rev. 974, is further developed. As before, models are placed in flow field of movable plate in test section of supersonic wind tunnel. Plate is now used as holder for three-component balance for half models. Balance is not described in detail. Paper gives calibrations of test section in field of plate and results of some three-component measurements on delta and trapezoidal wings. Reviewer considers method a useful one, especially for low supersonic Mach numbers (down to 1.1 in this case). W. A. Mair, England

1362. Miroux, J., On the measurement of gradients in electric-current analogies (in French), *Rech. aéro.* no. 29, 9–20, Sept./Oct. 1952.

Problems involved in measuring voltage gradient at a point in a liquid-filled analogy tank are reviewed. Description is given of several proposed high-accuracy apparatus for measuring the gradient at a point relative to that at another point where magnitude of physical quantity involved (e.g., velocity) is known. Method is to balance voltage difference across a pair of probes (fixed gap) with a known (variable) voltage, using oscilloscope as null indicator.

One rather elaborate unit was built and tested on several examples. Flow patterns (constant velocity lines) are given of incompressible flow about a circular cylinder, a sphere, and an airfoil section in proximity of ground, as well as compressible flow in convergent portion of tunnel nozzle. Experience shows that accuracies of at least 0.5% can be obtained under normal experimental conditions. J. S. Isenberg, USA

1363. Bull, G. V., Investigation into the operating cycle of a two-dimensional supersonic wind tunnel, *J. aero. Sci.* 19, 9, 609–614, Sept. 1952.

The starting phases, one nonstationary and one quasistationary, of an intermittent supersonic wind tunnel are theoretically and experimentally treated. The nonstationary phase is studied by application of an approximate theory due to Guderley. The quasistationary phase is studied by extending the stationary supersonic-subsonic jet theory, in which the jet-exit static pressure is less than the pressure in the region into which the jet is issuing. A better reproduction of the illustrations would be desirable. Erik Petersohn, Sweden

1364. Folsom, R. G., Nozzle characteristics in high-vacuum flows—rarefied gas dynamics, *Trans. ASME* **74**, 6, 915–918, Aug. 1952.

Experimental results are presented for high-vacuum gas flow through three nozzles ranging in size from 0.125-in. to 9.00-in. throat diam, with upstream pressures of 25 to 22,800 microns of mercury. The range of Reynolds number covered was 0.5 to 2000. Measured discharge coefficients varied from 0.1 to 0.9. The importance of the effect of pressure-tap location and installation geometry on measured coefficients was demonstrated. Results also demonstrated a distinctive breakaway characteristic developed when the pressure ratio across the nozzle decreased. Tests were conducted in region where slip flow may be appreciable, but no attempt was made to evaluate said effect. Authors acknowledge the necessity for additional work before the knowledge of viscous compressible metering with nozzles is satisfactory.

Robert J. Mindak, USA

1365. Deschere, A. R., Basic difficulties in pulsating-flow metering, *Trans. ASME* **74**, 6, 919–923, Aug. 1952.

Author presents a new approach to the solution of the pulsative-flow metering problem. The approach uses a time-dependent term in the energy and continuity equations, resulting in a nonlinear partial differential equation. Author discusses certain pulsative phenomena to substantiate the use of the time-dependent term. Paper infers past analytical work on secondary element has been to little avail, when pulse amplitudes are of any magnitude, as the major error is due to the primary element. Some 83 references are given. C. Newman, USA

Thermodynamics

(See also Revs. 1241, 1351, 1359, 1378, 1381)

1366. Haywood, R. W., The thermodynamic properties of saturated water, *Instn. mech. Engrs. Proc. (B)* **1B**, 2, 49–57, 1952.

Callendar's equation for the enthalpy of saturated water is used with the Clapeyron equation to graphically represent the thermodynamic properties of saturated water on the T-S plane. A "Gibbs line" is introduced which allows for the representation on the T-S plane of $\int VdP$ for a process along the saturated liquid line.

Callendar's hypothesis, that saturated water contains in solution its own volume of saturated steam, is examined and an extension is proposed to better check experimental data. The extension assumes that a lesser amount of steam is in solution and that the amount can be related to Callendar's theory. The

extension is discussed in terms of Eyring's "hole theory" for liquids. It is suggested that other saturated liquids could be analyzed in a similar fashion if accurate experimental data are available. William H. Roberts, Jr., USA

1367. **Altman, D., and Lorell, J., Effect of local variations in mixture ratio on rocket performance,** *J. Amer. Rocket Soc.* **22,** 5, 252–255, Sept.-Oct. 1952.

Effect is analyzed with regard to arbitrary modes of such variation. Results show that the effect in question can be evaluated by referring to a curve of theoretical specific impulse vs. weight fraction. In particular, if such a curve has a negative second derivative everywhere, then local variation in mixture ratio can only decrease performance. If there is a region with positive second derivative, then local variations in mixture ratio may improve performance; if these variations could be controlled, the maximum performance so obtainable would be on the double tangent near the over-all mixture-ratio point.

From authors' summary by J. Wisdom, Australia

1368. **McDonald, G., Flame propagation in carbon monoxide,** *J. chem. Phys.* **20,** 9, 1497–1498, Sept. 1952.

Author has made burning velocity measurements by the shadowgraph technique for dried mixtures of oxygen and air with carbon monoxide. The results are applied to the work of Tanford and Pease and show a discrepancy between the equations and the experiments of the latter. The conclusion is drawn that the latter results are dependent on hydrogen atom concentration, therefore the flame velocity for equal carbon-monoxide/oxygen ratios will lie on different curves for each value of the hydrogen atom concentration. H. M. Spivack, USA

1369. **Kippenhan, C. J., and Croft, H. O., The effect of high-frequency sound waves on an air-propane flame,** *Trans. ASME* **74,** 7, 1151–1154, Oct. 1952.

See AMR **5,** Rev. 1540.

1370. **Olsen, H. L., Edmonson, R. B., and Gayhart, E. L., Microchronometric schlieren study of gaseous expansion from an electric spark,** *J. appl. Phys.* **23,** 10, 1157–1162, Oct. 1952.

Sparks of 0.45-microsec duration were discharged through flowing gas to study growth of heated kernel of gas. Method is reproducible to the extent that a series of separate flash schlieren pictures, taken of kernels at successively greater delays after spark, gives a series of pictures equivalent to a motion picture taken at four million frames per sec. Details of equipment and method of taking such pictures are described.

Pictures show initial rapid expansion of gases after spark discharge. Shock wave separates from hot gases after 2 microsec, and hot gases continue to expand subsonically. At 15 microsec, the hot gas kernel becomes an ellipsoid, and by 112 microsec it has developed into a torus. The kernel continues to grow if ignition has occurred, but decays if it has not. Internal energy of the kernel varies with time, and that part of the energy transferred from the spark is distributed throughout the atmosphere as the work required to expand the kernel. That part of the energy remaining in the kernel is available for ignition purposes.

T. P. Clark, USA

1371. **Tsien, H. S., Servo-stabilization of combustion in rocket motors,** *J. Amer. Rocket Soc.* **22,** 5, 256–262, 268, Sept.-Oct. 1952.

Combustion instability is attributed to the pressure-dependent time delay between instants of injection and burning of liquid fuel. Earlier result is verified that stability for constant injection rate is sometimes possible regardless of the delay time. Paper shows that stability independent of delay time is seldom possible when feed-system dynamics is included. However, if the combustion-chamber pressure is fed back through a servo actuating a volume capacitance in the feed line, stability can be assured if the servo transfer function is properly chosen. Examples illustrate stable and unstable systems, and show how the servo function is determined.

Stability analysis utilizes the variant of the Nyquist diagram, called Satche diagram, applicable when pure-delay lag is involved. The complex-plant plot has two parts, a unit circle corresponding to pure delay, and a remainder. If the remainder plot never enters the unit circle, the system is stable for any delay time; otherwise there is a maximum allowable delay. Less simple cases involve both Nyquist and Satche diagrams.

Reviewer believes with author that both the method of analysis and the concept of feedback combustion stabilization have wide applicability. M. S. Silberstein, USA

1372. **Neubert, U., Longitudinal vibrations of flames in closed elongated combustion bombs** (in German), *Z. angew. Phys.* **4,** 4, 121–126, Apr. 1952.

Propane-air mixtures were ignited near one end of a long closed chamber. A series of schlieren pictures were taken of the propagating flame and of the motion of the unburned gas. Observation of the latter was made possible by introduction of fine (dry or oily) heated wires which produced small regions of density change that were presumed to follow the flow. Authors show that the slow oscillations observed are associated with reversal of flow in the unburned gas, quenching of the flame at the walls, and a splitting of the flame front. Bruce L. Hicks, USA

1373. **Reiss, H., The statistical mechanical theory of irreversible condensation. I,** *J. chem. Phys.* **20,** 8, 1216–1227, Aug. 1952.

A theory of nucleation, based on statistical mechanics, is presented. The problem reduces to the computation of the multiple occupation, by molecules, of cells, this being accomplished through the evaluation of the configuration integral for a supersaturated assembly. The new theory does not consider the first fragments of the stable phase formed to be spherical liquid drops. In no place (not even at the nucleus) is it necessary to consider explicitly phase equilibrium between an embryo and the mother phase. The manifold difficulties connected with this point (in view of the small dimensions of typical nuclei) are therefore obviated. Furthermore, it is possible to define an embryo unambiguously and in such a manner that its energetic properties can, in principle, be computed. This is not possible in the classical theory.

Certain limitations on the application of Einstein fluctuation theory to supersaturated systems are demonstrated.

From author's summary by S. S. Penner, USA

1374. **Yang, C. N., and Lee, T. D., Statistical theory of equations of state and phase transitions. I. Theory of condensation. II. Lattice gas and Ising model,** *Phys. Rev.* (2) **87,** 3, 404–419, Aug. 1952.

Article concerns the statistical theory of the equations of state and of phase transitions. It attempts to explain the discontinuities that occur in some thermodynamic functions associated with phase transitions. The problem is that of an infinite sample of a lattice gas, with attractive interaction between nearest neighbors. The analytical behavior of the thermodynamic functions is revealed by allowing the fugacity to take on complex values. The study is reduced to the investigation of the distribution of roots of the grand partition function. The non-

existence of the liquid phase in Mayer's theory is explained; the problems, of the Ising model in a magnetic field and of the lattice gas, are proved mathematically equivalent.

The surprising results derived from the theorems proved are applicable to a large class of practical problems.

H. D. Vasileff, USA

1375. Oguchi, T., and Takagi, Y., Statistical theory of rotational phase transition. I, *J. phys. Soc. Japan* **7,** 2, 145–152, Mar./Apr. 1952.

The method of approximation introduced by Kikuchi [*Busseiron Kenkyu* **24,** p. 52, 1950] into the order-disorder problem is applied in the present paper to transitions due to molecular rotation. In this approach an approximate expression for the entropy of the crystal in terms of the probability distributions appropriate to a single elementary cell plays a decisive part. Calculations made for a two-dimensional net of molecules result in a finite and discontinuous specific heat at the transition point. Reviewer notices that this result is similar to that of the older approximate theories of the order-disorder transition, whereas, in that case, the exact treatment yields an infinite specific heat. Quantitative data as obtained by author can hardly be considered as being very accurate. R. Eisenschitz, England

1376. Laird, A. D. K., Stability of gas flow in a tube as related to vertical annular gas-liquid flow, Heat Transfer Fluid Mech. Inst., Stanford Univ. Press, 37–52, 1952. $5.

Upward flow through a vertical tube of a central gas column and a liquid annulus is studied. The pressure drop for the liquid phase calculated from the Navier-Stokes equation agrees reasonably well with experiment, but the corresponding computed pressure drop in the gas column is too low by a factor of 10–100. A linearized mathematical treatment, assuming laminar flow in both phases, of the effect of the waves observed at the gas-liquid interface does not account for the discrepancy.

Author then investigates the effect of these waves on the gas flow experimentally by measuring the friction and velocity distribution of air flowing through a rubber tube subjected to axisymmetric waves. These standing waves produced the increased frictional resistance noted in gas-liquid flow and promoted the onset of turbulent flow. William Squire, USA

1377. de Klerk, D., Methods of determining very low thermodynamic temperatures. Measurements with potassium-chromium-alum, "Low-temp. Physics," *Nat. Bur. Stands. Circ.* 519, 211–222, Oct. 1952.

Temperature determination below 1 K is difficult because of inapplicability of gas thermometry. Paper discusses four methods of relating thermometric parameters to absolute temperature T. These methods, applied to potassium chromium alum, give fairly consistent results. At lowest temperatures, of order of 0.003 K, the best accuracy in T is about 10–20%.

Aaron Wexler, USA

Heat and Mass Transfer

(See also Revs. 1146, 1338, 1348)

1378. Beenakker, J. J. M., Taconis, K. W., Lynton, E. A., Dokoupil, Z., and Van Soest, G., Heat conduction in helium II containing some ^{3}helium, *Physica* **18,** 6/7, 433–447, June/July 1952.

In a research in low-temperature physics, authors measure the heat resistance of liquid helium II. The measurements were made at various concentrations of the rare helium isotope of mass three between zero and 2.8×10^{-4} and in the temperature range between 1.20 K and 2.10 K. The heat resistance at a given temperature in this range was found to be proportional to the concentration of ^{3}helium in the mixture. This proportional relationship is advanced as a means whereby an unknown concentration of ^{3}helium could be determined from measurements of the heat resistance of liquid helium II. A method is presented whereby the diffusion constant of ^{3}helium in ^{4}helium can be calculated from a knowledge of the heat resistance and the concentration of ^{3}helium. Donald M. Vestal, Jr., USA

1379. Meixner, J., On the theory of heat conductivity of reacting fluid mixtures (in German), *Z. Naturforsch.* **7a,** 8, 553–559, Aug. 1952.

The heat conductivity of a mixture of reacting fluids is increased above the heat conductivity at frozen reaction by the following contributions: Diffusion of energy of reaction, heat conductivity by thermodiffusion and by diffusion thermic. The influence of the first contribution for a dissociating gas was calculated previously by W. Nernst. Present paper extends calculations to mixtures of arbitrary fluids and includes, additionally, the other effects. Numerical evaluations show influence of thermodiffusion and diffusion thermic to be usually relatively small (especially large—between 1 and 5%—for $N_2O_4 = 2\ NO_2$). In these calculations, local chemical equilibrium in the heat conducting gas was assumed. Additional calculation based on kinetic theory investigates influence of finite reaction velocity on heat conductivity. At normal pressure this influence is again usually small (for dissociating N_2O_4 smaller than 5%). At low pressures it may become appreciable. E. R. G. Eckert, USA

1380. Bosworth, R. C. L., Heat transfer phenomena. The flow of heat in physical systems, Sydney, Assoc. Gen. Publ. Pty. Ltd.; New York, John Wiley & Sons, Inc., 1952, xii + 211 pp. $6.

Monograph is an excellent concise review of recent developments in all fields of heat transfer which is treated as an example of transport phenomena. Familiarity with the subject is assumed; however, this book could be used as text for advanced courses, as it serves as an excellent guide to the recent literature in the field.

Book should be of about equal value to students and to busy engineers in industry (for home-study purposes).

W. L. Sibbitt, USA

1381. Taylor, C. F., Heat transmission in internal combustion engines, Gener. discuss. heat transfer, Lond. Conf., Sept. 11–13, 1951. Sect. V. London, Instn. mech. Engrs., New York, ASME, 5 pp.

Author discusses heat transfer in familiar I.C. engine configurations, wherein the complicated process of heat exchange between working gas and cylinder wall, head, and valve face is assumed to be a steady-state, forced-convection, mean-property process encompassed by a typical Nusselt-Reynolds-Prandtl correlation. A surprisingly substantial correlation of this sort is exhibited for a few experimental temperature measurements on inner surface of cylinder head and exhaust valve face, assuming constant properties and identical heat-transfer process in combustion chamber and cooling passage.

Paul J. Schneider, USA

1382. Yih, C.-S., Laminar free convection due to a line source of heat, *Trans. Amer. geophys. Un.* **33,** 5, 669–672. Oct. 1952.

The temperature and velocity distributions in an originally

isothermal motionless fluid, above a line source of heat in an infinite horizontal plane, are obtained for the steady state, in a closed form for laminar free convection.

Solution is based on equations for free convection as assumed by Schmidt, Pohlhausen, and Beckmann in 1930 ["Heat transfer notes," Boelter et al., Univ. Calif. Press, pp. XII–29, 1948]. Dimensional analysis is used to obtain a variable which reduces the partial differential equations to ordinary differential equations. A closed solution of these equations is obtained. Solution is valid for Prandtl numbers of 2/3 and 7/3.

No bibliography is contained in paper, and Equation 17 appears to be a misprint. W. A. Wolfe, Canada

1383. **Drakhlin, E., On heat convection in a spherical cavity** (in Russian), *Zh. tekh. Fiz.* **22**, 5, 829–831, May 1952.

Solutions of differential equations are given for weak thermal convection currents of an incompressible fluid in a hollow sphere by successive approximations. The cavity is supposed embedded in an infinite solid and the temperature gradient at infinity is prescribed. Assuming the same basic equations as E. M. Zhukovitskiĭ [see AMR **6**, Rev. 644], author develops equations for stream function U and temperature difference T' and gives appropriate polynomials as first-order approximations for T' and for velocity components. Second-order approximations for velocities are polynomials of seventh degree, which can be found by solving a system of 44 linear algebraic equations.

A. Kuhelj, Yugoslavia

1384. **Surinov, Yu. A., On functional equations of heat radiation in presence of an absorbing and dispersing medium** (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **84**, 6, 1159–1162, June 1952.

The partial differential equation for energy transfer in an absorbing and dispersing medium is discussed. Different aspects of this process are mentioned and, in some special cases, integrals are found and discussed. D. ter Haar, Scotland

1385. **Stĭrikovich, M. A., and Kholodovskiĭ, G. E., Investigations of the circulation in vapor-generating pipes at high pressures of water vapor** (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 4, 506–528, Apr. 1951.

Experiments were conducted at the Energy Inst. Acad. Sci. USSR to study circulation velocity in unheated vertical pipes of 56-mm diam, for high vapor pressures (180–200 kg/cm²). Data were compared with previous results for narrower (25.5 mm) pipes and for lower pressures (35 and 64 kg/cm²). Curves are given showing dependence of useful heat on circulation velocity and reduced steam velocity for various pressures; dependence of slip loss on circulation velocity; dependence of relative steam velocity with moving water-vapor mixture on circulation velocity of volume of steam maintenance. Authors conclude that, with increasing steam pressure, circulation velocity and reduced steam velocity, slip loss decreases; useful head in pipes of 50–60-mm diameter may be calculated from $p_{use} = \beta H(\gamma' - \gamma'') - \Delta p_{theor}$(*) for pressures of 180 kg/cm² and above, as well as for pressures of 140 kg/cm² and 110 kg/cm² with the respective circulations $w_0 \geq 0.5$ and 0.7 m/sec. For smaller diameter pipes (*) may be used for pressures of 180 kg/cm² and above.

Morris D. Friedman, USA

1386. **Bergelin, O. P., Brown, G. A., and Doberstein, S. C., Heat transfer and fluid friction during flow across banks of tubes. IV,** *Trans. ASME* **74**, 6, 953–960, Aug. 1952.

Paper is a presentation of experimental results of flow and heat transfer of oil (gulf 896) across banks of tubes of various configurations. Variations of heat-transfer coefficients and friction factors with Reynolds numbers are plotted for various positions of banks of tubes with respect to the direction of flow. The investigation mentioned extends for a wide and important range of Reynolds number—between 100 and 10,000. This range covers completely the transition region, and, with the work of Bergelin for the laminar region and Grimson's work for the turbulent region, authors correlate their findings to give a much wider region of interest. The investigations were carried out with tubes $^3/_8$ in. in diam and pitch-to-diameter ratios of 1.25 and 1.50.

S. Eskinazi, USA

1387. **Fischer, J., Stationary temperature of long wires traversed by a current** (in German), *Arch. Elektrotech.* **40**, 4, 262–274, 1952.

Paper formulates analytical solutions to the problems of heat transfer from wires and slender rods heated by the flow of electricity. A long linear electrical conductor having constant cross-sectional area and surrounded by liquid, gas, or vacuum is considered. A general relation expressing the difference between the conductor surface temperature T and the ambient temperature T_0 is written. The effects of power, current, potential and conductor cross-sectional areas are studied separately for five different functions defining the heat loss in terms of the temperature difference $T - T_0$. A. B. Cambel, USA

1388. **Vasileff, H. D., On the calorimetric heat exchange correction,** *J. appl. Phys.* **23**, 9, 979–983, Sept. 1952.

Paper considers the determination of the heat capacity of a cylindrical sample of material of finite thermal conductivity by determining the thermal time constant of the system in a transient state. The time lag and the temperature gradient between the heated surface and the point of temperature-time observation that result by virtue of the finite thermal conductivity of the sample are considered on an analytical basis. In this way, an accurate description of the experimental heating and cooling curves is obtained. Heat-capacity measurements in the region 65 K–300 K, on the basis of the correction for finite thermal conductivity of the sample, have yielded values approximately 2% higher than similar measurements considering the thermal conductivity to be effectively infinite. R. M. Drake, Jr., USA

1389. **Michels, A., and Botzen, A., A method for the determination of the thermal conductivity of gases at high pressures,** *Physica* **18**, 8/9, 605–612, Aug./Sept. 1952.

A description is given of an apparatus, based on the parallel plate method, for the determination of the thermal conductivity of gases at elevated pressures. The design of the instrument is described, and an account is given of the method of calculating the conductivity coefficient from the experimental data. The accuracy achieved is about 1%. From authors' summary

1390. **Webb, F. J., Wilkinson, K. R., and Wilks, J., The thermal conductivity of solid helium,** *Proc. roy. Soc. Lond. (A)* **214**, 1119, 546–563, Oct. 1952.

The thermal conductivities of crystals of solid helium at densities between 0.194 and 0.218 g/cm³ have been measured at liquid-helium temperatures. In order to interpret the results, the specific heat of solid helium at these densities has been measured from 0.6 to 1.4 K. The range of densities employed is sufficient to allow the observation of Debye characteristic temperatures varying by 40%, and of thermal conductivities varying by factors of over 10. It is shown that the conductivity measurements are in accord with the 'umklapp' type of thermal resistance derived by Peierls (1929, 1935).

Further work was restricted by the difficulty of obtaining good single crystals in narrow tubes, but measurements of the conductivity at one density were obtained down to 0.3 K. In this region, the conductivity is limited by boundary scattering and is higher than that observed by other authors for liquid helium II at similar temperatures. From authors' summary

1391. Bammert, K., Heat transfer in flow around reaction blades with inner cooling (in German), *Forsch. Geb. Ing.-Wes.* (*B*) **18**, 3, 81–94, 1952.

Author measured heat-transfer coefficient of a metallic blade with drilled holes for cooling in a cascade of wooden blades at different blade pitches, air flow angles, and air speeds. The stagger angle of cascade was kept constant. The blade was heated inside with saturated steam through the drilled passages. The measured surface temperatures were recalculated for actual turbine blades heated by hot gas and cooled from the holes inside. In this case, temperature at trailing tip seems to be too high. Results of heat-transfer coefficient are given as an exponential relation between Reynolds number and Nusselt number. The exponent was found to be the same for the air angles and blade pitches measured. Only the proportionality factor varies.

Author uses static temperature of air to calculate heat-transfer coefficient. Reviewer thinks stagnation temperature more suitable, being nearer to the adiabatic wall temperature and more readily obtained. In general, measurement seems to be carefully performed. L. S. Dzung, Switzerland

1392. Scesa, S., and Sauer, F. M., An experimental investigation of convective heat transfer to air from a flat plate with a stepwise discontinuous surface temperature, *Trans. ASME* **74**, 7, 1251–1255, Oct. 1952.

The objective of the investigation was to obtain turbulent forced convective heat-transfer data for air flowing parallel to a flat plate with a stepwise discontinuous surface temperature. Heat was supplied by fifteen transverse nichrome ribbons on the upper and lower surfaces of a bakelite plate. The electrical input to each ribbon was controlled separately so that the surface-temperature distribution could be maintained constant or stepwise. Local heat-transfer coefficients were obtained from the measured ribbon temperature and the electrical heat input to each ribbon. The experimental results were correlated with the Colburn equation with $\pm 6\%$ for a range of local Reynolds modulus from 60,000 to 800,000 by use of the starting-length correction of Rubesin. The starting length is defined as the position where the step occurs in the surface temperature.

From authors' summary

Acoustics

(See also Rev. 1306)

1393. Meyer, E., and Tamm, K., Wide-band absorber for water-borne sound (in German), *Akust. Beihefte* no. 2, AB91–AB104, 1952.

Absorbent layers for tank walls are needed to produce well-defined sound fields; 10% amplitude reflection and frequency range 5–50 kc are limits considered here. Although resonant absorbers require thinner layers, they are more critical and frequency-sensitive, so nonresonant type is preferred. For airborne sound, porous absorbers are used, theory is briefly described; but in water these are not efficient. Instead, try different absorption mechanism using material showing elastic aftereffect; losses now depend on compression of material rather than relative motion in pores, and mechanism is better suited to sound in water. Theory of this type of absorber is briefly described using complex compressibility; formulas are similar to porous materials, but frequency dependence is different. Desirable decrease of volume elasticity (decreases layer thickness) is achieved by filling material with pores of air. Problem of choosing layer thickness to minimize reflection, taking account of terminal resistance of layer is considered in detail and verified by measurements. Best materials give minimum reflections 20–30%; it is difficult to make practical materials to meet all conditions. Essential improvement is obtained by use of absorbers separated by channels of water; reflection-free transition from water to absorber is obtained by tapering the compressibility or the cross sections of the absorbers (e.g., pyramids projecting into water from walls). Same materials as in compact layer measurements now give reflections 10–20%. Variety of materials sheathed in aluminum foil are tested, size and spacing of absorber sections being varied to find optimum values. High and low frequency behavior of these structures with canals are qualitatively discussed, giving references to theory, and verified by measurements; canal length determines low, and canal width high frequency limits. Measurements are given of effects of varying transition (i.e., the taper) from water to absorber, of directional dependence of the reflection, of temperature and pressure dependence. Bad effects of absorption of water are noted, and avoidance by using rubber with enclosed holes is described. For experiments requring smooth walls, a transparent rubber sheet is described which can screen off the rough absorbing wall.

Paul Marcus, USA

1394. Jones, E., Edelman, S., and London, A., Long-tube method for field determination of sound-absorption coefficients, *J. Res. nat. Bur. Stands.* **49**, 1, 17–20, July 1952.

Method uses an impedance tube with standing wave. A loudspeaker is mounted on one end of the tube. The opposite end is closed by the acoustic material being tested. A microphone is moved along the tube in order to find out and to measure maximum and minimum pressure. Tube is 30 in. long and $9^3/_4$ in. in diam, operating frequency is 512 cps; so, one maximum and two minima are produced. Sound-absorption coefficient is calculated by $4r/(1 + r)^2$, where r is ratio between maximum and minimum pressure. The relationship between the tube absorption coefficient, corresponding to the normal incidence, and the reverberant absorption coefficient, corresponding to the random incidence, is presented by a formula and by a table. A great number of samples were tested by both methods. Comparison shows that the results are in satisfactory agreement when, on an average, a difference of 0.07 is assumed as failing in the tube results. Nevertheless, as the samples may be tested wherever installed, however respectively conditioned, the tube method is of great importance for objective evaluation of various factors to be considered in the application of acoustic material. On the contrary, the reverberant method requires material to be mounted on the wall of the reverberant chamber, and there the conditions are always the same. P.-P. Heusinger, Germany

1395. Nolle, A. W., and Sieck, P. W., Longitudinal and transverse ultrasonic waves in a synthetic rubber, *J. appl. Phys.* **23**, 8, 888–894, Aug. 1952.

Object of paper is to investigate the dependence of velocity and attenuation of both longitudinal and transverse ultrasonic waves propagating in rubberlike materials on frequency and temperature. Measuring of transverse waves is enabled by using solid transmission blocks, which conduct the pulsed ultrasonic signals into the flat and thin sample. This is an efficient improvement of the method used previously, extending also the investigation

(due to reduced attenuation) to lower temperatures. Results of measurements show decreasing character of velocity dependence with increasing temperature, while attenuation dependence with temperature has a remarkable peak value. In consequence of detailed study of results, authors also demonstrate that longitudinal wave losses in the tested sample are substantially due to relaxation phenomena measured in shear rather than in compression. An exact expression of this is not yet possible, due to considerable quantitative uncertainty of transverse wave measurements arising from experimental errors.

From authors' summary by V. Kopřiva, Czechoslovakia

1396. **Koppelman, J., Ultrasonic measuring technique in fluids** (in German), *Acustica* **2**, 2, 92–95, 1952.

An ultrasonic probe microphone is described in which a rubber tube covers all but the tip of a fine (0.5-mm) wire. The tube material is a poor conductor of sound, and the tube touches the wire at the ends only. Piezoelectric or magnetostrictive transducers may be used, and two wires may be employed for a gradient microphone. The microphone has been used up to 500 kcps, although tuned amplifiers are necessary. It was employed in the measurement of radiation pressure by modulating the 500-kcps generator at 1.5 kcps and tuning the microphone amplifier to that frequency; the expected output due to varying radiation pressure was found. Vincent Salmon, USA

1397. **Barone, A., Aspects of the concentration of ultrasonic energy,** *Acustica* **2**, 5, 221–225, 1952.

The advantages offered by reflecting concentrators as compared with acoustic lenses in producing ultrasonics at high power are discussed, and two types of concentrators capable of direct application to the usual quartz holders for vertical emission described. There follows a qualitative consideration of the structure of the ultrasonic field obtained by these systems.

From author's summary

1398. **Kishimoto, T., and Nomoto, O., Ultrasonic absorption in carbon disulphide,** *J. phys. Soc. Japan* **7**, 5, 537–538, Sept./Oct. 1952.

Experimental results of absorption of ultrasonic waves in CS_2 are given and compared with existing absorption data. A theoretical absorption curve which fits the new and existing data well is also given. M. S. Macovsky, USA

1399. **Makinson, K. Rachel, Transmission of ultrasonic waves through a thin solid plate at the critical angle for the dilatational wave,** *J. acoust. Soc. Amer.* **24**, 2, 202–206, Mar. 1952.

Paper deals with total reflection of incident sound waves from solid plates of thickness comparable to dilatational wave length in the material. Experimental procedure, employing use of small-angle wedge of material to be studied, is given in brief résumé, as are fundamental equations of pertinent theory.

Author shows that, due to existence of rotational wave, there exists a region about the critical angle in which sensibly total reflection or no transmission of dilatational waves occurs, in contradiction to previous theory for case of thin plates. Author also points out applicability of total-reflection method with thin specimens to obtain dilatational-wave velocity in material.

Paul Tamarkin, USA

1400. **Meixner, J., General theory of sound absorption in gases and liquids with consideration of the transport phenomena** (in German), *Acustica* **2**, 3, 101–109, 1952.

Author presents a phenomenological theory of sound absorption and dispersion in liquids and gases, using the methods of thermodynamics of irreversible processes [see, e.g., De Groot, AMR **5**, Rev. 240, or the feature article by Prigogine, AMR **5**, p. 193]. The theory takes into account transport phenomena (heat conduction, diffusion, thermodiffusion, and viscosity) as well as very general relaxation processes (author calls them "innere Umwandlungen") in which also deviations from the thermodynamic equilibrium during a cycle of the vibration may occur, as, for instance, in the case of a medium consisting of chemically reacting components. The theory is based on the following eight equations: (a) Gibbs' relation $dU = T\,dS - P\,dV - A\,dx$ with U, S, V specific energy, entropy, volume; T temperature, P pressure, A affinity, x concentration of a component. This relation is the basis for the entropy balance. (b) Four equations expressing the balance of mass, momentum, energy, and concentration. (c) Three linear relations between generalized "fluxes" and generalized "forces": (c_1) between the tensor of the relative velocities and the stress tensor; (c_2) between energy flux and the gradients of temperature and affinity; (c_3) between diffusion flux and the gradients of temperature and affinity.

Several particular cases are discussed in detail and it is shown that, for the whole frequency range, the total absorption may approximately (but not rigorously) be obtained as the sum of the absorptions due to the transport phenomena and the relaxational processes alone. H. L. Oestreicher, USA

1401. **Bradbury, C. H., The measurement and interpretation of machinery noise with special reference to oil engines,** *Instn. mech. Engrs. Proc.* (*B*) **1B**, 1, 1–8, 1952.

Paper attempts to deal with the problem of machinery noise from the engineer's viewpoint, and particular consideration is given to oil-engine noise. An examination is made of commercial methods of noise measurement, illustrated by examples from various types of machinery. An attempt is made to correlate diagrams obtained by measurement and known sources of engine noise. Methods of noise reduction are examined. Brief reference is made to the acoustic hood and the possibilities of its use in residential districts. Paper is restricted to an examination of airborne noise. From author's summary

1402. **Berry, F. J., The diffraction of sound pulses by an oscillating infinitely long strip,** *Quart. J. Mech. appl. Math.* **5**, part 3, 324–332, Sept. 1952.

Title problem was considered by Fox [see AMR **2**, Rev. 528] in the case of an immovable strip. Author extends analysis to spring-supported strip with finite inertia. Numerical results are given for pressure on and velocity of strip during early part of motion, when inertia effects predominate. Four different values of mass (relative to appropriate air mass) are used in calculations, covering range from very heavy (approaching stationary) to very light strips. Application to blast studies are discussed.

J. W. Miles, USA

1403. **Berry, F. J., The diffraction of a sound pulse by a non-rigid semi-infinite plane screen,** *Quart. J. Mech. appl. Math.* **5**, part 3, 333–343, Sept. 1952.

Continuing his previous investigation (see preceding review) of diffraction by spring-supported strip of finite width, author considers semi-infinite screen of finite areal density, each particle of which can yield independently under pressure of incident pulse. Method of solution is reduction to sequence of Abel integral equations [F. G. Friedlander, AMR **5**, Rev. 621; E. N. Fox, AMR **2**, Rev. 528; cf. H. Bateman, "Partial differential equations," Dover Publ., N. Y., p. 487, 1944]. Numerical results for pressure vs. time are given for four values of the screen density parameter. John W. Miles, USA

1404. Severin, H., and Starke, C., Diffraction of sound waves at the aperture in a rigid screen (in German), *Akust. Beihefte* no. 2, AB49–AB66, 1952.

Sound pressure on axis of circular aperture and in plane of screen is investigated experimentally for ratios of radius to wave length of 0.5, 1, 1.5, 2, 3, and 4. Authors show that substantial agreement exists between theory and experiment. Prediction for diffracted pressure is based on Kirchhoff's approximate solution, which assumes a uniform distribution of dipoles on the aperture.

O. K. Mawardi, USA

1405. Lucas, R., On radiation pressures of sound waves (in French), *Atti Conv. Internaz. Ultracust.* 1950, 236–247, 1951.

An international congress on the applications of ultrasonics (in physics, engineering, biology and medicine) was held in Rome in 1950. Present paper was presented under the first of these subjects. Following the approach initiated by Brillouin and Fubini (for bibliography see *J. acoust. Soc. Amer.* **22**, 3, p. 318, May 1950, and **24**, 5, p. 468, Sept. 1952), author studies acoustic radiation pressure by placing emphasis on its tensorial character. He analyzes the radiation pressure exerted by a plane progressive wave on its source, on a perfectly absorptive surface, and on a partially reflective surface (he suggests a device, based on the analysis of this case, for measuring the reflectivity of a surface); he then derives the pressure of a spherical progressive wave on its source and of spherical standing waves, confined between two concentric spherical surfaces, on the outer surface. He finds that radiation pressures exerted by progressive and standing waves involve, respectively, the density of the kinetic and potential energy densities.

M. C. Junger, USA

Ballistics, Detonics (Explosions)

1406. Elghozi, C., Interaction of projectiles fired in volley by a multiple material (in French), *Mém. Artill. fr.* **26**, 2, 477–488, 1952.

If two projectiles are fired nearly at the same time from two barrels, adjoining and parallel (gun-turret), the differences in the range are unimportant if the interval between leaving the muzzles is very short (e.g., < 0.5 ms) or exceeds a greater value (e.g., >7.5 ms). In the interval between these two limits, the difference in range can be significant. Author supposes that the second projectile remains behind the first because it is disturbed by the first projectile's shock wave (more air resistance resulting from higher pressure and greater yaw). It may also be that the projectile is disturbed by its own shock wave, analogous to the case where a projectile is flying parallel to a wall at such a distance that its own shock wave after reflection strikes the boattail. In this case, the dispersion increased rapidly. Author mentions experiments made in Berlin, 1936/1937.

H. Schardin, Germany

1407. Hösli, H., Disturbances in the rocket flight through wind action and similar influences (in German), *Flugwehr und Technik* **14**, 8, 177–183, Aug. 1952.

Article deals with the effect of cross wind on the trajectories of ground-fired rockets, and of cross wind and side slip in rockets fired from aircraft. In order to make the equations integrable, several simplifying assumptions are introduced. Thus, thrust, mass, and moment of inertia of the rocket are assumed constant, the effect of gravity on the trajectory is neglected, and all angles are assumed to be small. The resulting equations for power flight and free flight can be integrated, although not always in terms of tabulated functions. Results are presented in form of graphs.

R. Drenick, USA

1408. Evans, W. M., and Taylor, Sir Geoffrey I., Deformation and fractures produced by intense stress pulses in steel, *Research* **5**, 11, 502–509, Nov. 1952.

Pulses were produced by H. E. detonated against cylindrical bar targets of high- and low-carbon steels and Armco iron. Deformation is illustrated by hardness and etching. Fractures are shown and classified. Discussion of scabbing and effect of spherical pulse are given.

J. Corner, England

1409. Dupuis, J., Interpretation of direct-fire ballistic shooting and its application (in French), *Mém. Artill. fr.* **26**, 2, 335–380, 1952.

Author improves the method of determination of the angle of elevation with which the Gavre commission experienced difficulties. He uses a parameter $Z = X - T(\Delta X\alpha/\Delta T\alpha)$, which is simultaneously a function of range X and time of flight T and is independent of the variation of angle of elevation. The effect of initial angle of yaw on X and T is investigated, and the discrepancy in angles of elevation reconciled. This discrepancy, in former tests, occurred when measurements at different distances of the screens from the point of departure were made. Author also treats the initial motion of the center of gravity of projectiles, the relation between retardation function and initial angle of yaw, the dispersion of the ballistic coefficients, and compares experimental results with this interpretation of the trajectory. Author believes that his systematic approach to the laws of resistance makes some old empirical coefficients obsolete and establishes experimental ballistics as a chapter of rational mechanics.

G. R. Graetzer, USA

1410. Senior, D. A., and Grove-Palmer, C. O. J., An improved technique for high speed photography, *Brit. J. appl. Phys.* **3**, 10, 318–321, Oct. 1952.

Authors describe apparatus for investigation of underwater-explosion phenomena. The apparatus consists of (*a*) photographic equipment (16-mm Fastax camera with a maximum speed of 4000 frames/sec) and associated light source (photoflash bulbs, fired at intervals of 16 msec); (*b*) piezoelectric gages (tourmaline) for measuring pressure in the water. The circuits used for controlling and synchronizing the various operations are described in detail.

R. M. Davies, Wales

Soil Mechanics, Seepage

(See also Rev. 1230)

1411. Vasil'yev, A., Fundamentals of the contemporary methods and techniques for determining physical properties of soils [Osnovi sovremennoĭ metodiki i tekhniki laboratorníkh opredeleniĭ fizicheskikh svoĭstv gruntov], Moscow, Izdat. Min. Stroit. Predpr. Mashinostr., 1949, 159 pp.

Some methods for determining physical (not mechanical) properties described in the book are very interesting; e.g., the determination of swelling. Very useful are theoretical explanations attached to each property. Reviewer finds as most interesting the chapters on molecular forces between water and soil particles. In this connection, problem of consistency limits is analyzed. With regard to the disturbance of soil in usual methods for determining LL, the cone test is introduced. Instead of PL, a new consistency limit called by A. F. Lebedev "maximum molecular absorption" is introduced. Lebedev showed that, under the influence of centrifugal forces in the interval of 20,000 to 70,000 times the gravitational forces, water content did not change. This water content is bound, therefore, by molecular forces. A simple equivalent method for determining this limit by means of

static pressure of 65 kg per sq cm is introduced. Method of soil classification based on this limit is given.

V. Mencl, Czechoslovakia

1412. **Habib, P., Marchand, R., and Tincelin, E., Measurement of rock pressure** (in French), *Ann. Inst. tech. Bât. Trav. publics* **5**, 58, 965–990, Oct. 1952.

Paper describes method of measuring rock pressures adjacent to tunnel or gallery. Strain gages are attached to vertical rock face, then horizontal slot is cut in rock face adjacent to gages and change in deformation observed as stress is relieved. A flat hydraulic jack (of type developed by Freyssinet for prestressing concrete) is then grouted into slot and pressure applied. Pressure at which strain gages indicate return to initial deformations is assumed to be equal to initial pressure in rock. Laboratory and field investigations are described in detail and results interpreted. Discrepancies are found to be explainable with aid of the elastic theory. C. P. Siess, USA

1413. **Jáky, J., Pressure against braces in cohesive soils** (in German), *Acta Techn. Hung. Budapest* **3**, 1/2, 121–129, 1952.

This posthumous publication of handwritten manuscript, edited by Á. Kézdi, assumes horizontal soil surface without surcharge, vertical back of retaining wall capable of offering frictional resistance, and soil with both friction and cohesion. Two further assumptions are made: (1) There is only one surface of failure; it is plane and passes through heel of back of wall. (2) Points of application of resultant force or all vertical plane sections above failure plane are located on straight line at midheight of these sections.

Equilibrium conditions of infinitely thin prisms bounded by vertical planes above failure plane give three equations with four unknowns. The fourth equation is provided by assumption (2).

Solution of the differential equations leads to following main findings: (A) The distribution of shearing stress on failure plane is parabolic and not linear, as usually assumed. (B) Total lateral pressure is smaller than value obtained by "classical" Coulomb equation.

It is claimed that finding (A) corresponds to results of field measurements in braced cuts. Reviewer agrees with this, but considers finding (B) doubtful and assumptions (1) and (2) definitely questionable. It should be noted that: (a) Observations in braced cuts contradict assumption (1) by showing that failure surface is not plane; (b) paper follows the "classical" theories of earth pressure by ignoring effect on shape of failure surface and on distribution of lateral earth pressure of nature of deformations and displacements of different types of retaining structures; this is main cause of discrepancy (a).

G. P. Tschebotarioff, USA

1414. **Craemer, H., Approximations following from the maximum condition applied in theories of plasticity and earth pressure,** *Publ. int. Assn. Bridge struct. Engng.* **12**, 79–90, 1952.

Paper discusses limit loads for frames, plates, and earth pressure. Examples are given showing that the choice of position of yield hinges in frames, of fracture lines in slabs, and of sliding surfaces in earth-pressure problem has but little influence on the failure load. No general proofs of general methods of estimating the error are given. P. G. Hodge, Jr., USA

1415. **Duke, C. M., Field study of a sheet-pile bulkhead,** *Proc. Amer. Soc. civ. Engrs.* **78**, Separ. no. 155, 26 pp., Oct. 1952.

Methods and results of a field study of the structural performance of a flexible anchored bulkhead are presented. The bulkhead retains a 55-ft height of fine-sand hydraulic fill in Long Beach Harbor, California. A coarse granular dike extends for half the height on both inside and outside. Instrumentation was provided for the measurement of soil pressure, pore pressure, tie-rod tension, and deflection during and after the filling operation.

During filling, the lateral soil-pressure distribution was approximately in proportion to the weight of the overlying fill, with a lateral pressure coefficient of approximately 0.7. After the completion of filling, the lateral pressures above the wale increased sharply and those below decreased. This change is attributed to the settlement of fill and the accompanying partial support of fill on the tie rods and wale. The inner dike was effective in reducing outward soil pressures on the bulkhead. The outer dike provided some passive resistance to deflection and served to confine the bulkhead foundation.

From author's summary

1416. **Verdeyen, J., and Roisin, V., A new method for the calculation of metallic sheet piles and of bulkheads of deep trenches** (in French), *Ossature métall.* **17**, 4, 207–219, Apr. 1952.

Authors discuss various methods of designing supports for excavations. On the basis of empirical evidence, a modified "equivalent beam" method is suggested. Reviewer believes that the suggested modifications require further field investigations, especially on strutted bulkheads, before the new method can be used with confidence. G. G. Meyerhof, England

1417. **Verdeyen, J., and Roisin, V., New theory of support of deep excavations** (in French), *Ann. Inst. tech. Bât. Trav. publics* **5**, 54, 601–626, June 1952.

1418. **Berezantsev, V. G., On design of sandy foundations of hydraulic structures** (in Russian), *Gidrotekh. Stroit.* no. 7, 34–40, July 1952.

Paper deals with determination of the ultimate load on a foundation resting on a cohesionless material, the failure condition being characterized by formation of limiting state of equilibrium in the underground. The theoretical methods of V. V. Sokolovskiĭ, devised for this purpose, are too involved for practical use, and author sets out to simplify them, which he does at times in a somewhat arbitrary manner. Several cases are considered, involving both vertical and inclined loads. Strongly eccentric load on the foundation results in formation of a one-sided wedge of rupture, sliding in the direction opposite to eccentricity, while central or slightly eccentric load results in two wedges being pushed sideways by the third wedge formed directly under the foundation. Comparison of the ultimate loads, determined by author's method, with some experiments is not good, although no worse than by other theoretical methods.

Author also performed some experiments with models involving glass side wall, which allowed observation of the underground, made conspicuous by horizontal streaks of chalk. Agreement of the shape of the surface of rupture with the theory, which was the object of these experiments, has been found satisfactory by author. To reviewer, however, these experiments appear very crude because of friction on the glass, difficulty of compaction without disturbing the streaks of chalk, and the extreme amount of vertical displacement which, in one case, was as great as the width of the model. Alexander Hrennikoff, Canada

1419. **Lapuk, B. B., and Evdokimova, V. A., Motion of liquids and gases in a porous medium in case of coexistence of different filtration regimens** (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **76**, 4, 509–512, Feb. 1951.

The general law

$$|v| = Ck^{(3n-1/)2}\mu^{(1-2n)}\rho^{(n-1)}(dp/dr)$$

established by dimensional analysis, relates velocity of filtration v to the porosity k, absolute viscosity μ, density ρ, and pressure p, and radial distance from the sink r. C is a dimensionless coefficient related to the Reynolds number, and n is called the exponent of the filtration law, and is, in some of the authors' examples, also dependent upon the Reynolds number. Upon integration of this formula, authors find an expression for pressure within a given layer. Numerical examples comparing their results with the usual case ($n = 1$) are given. R. E. Gaskell, USA

1420. Serre, F., The fundamental problem of settlement of clayey layers, *Génie civ.* **129,** 14, 15; 263–266, 286–289; July, Aug. 1952.

Author gives the mathematical solution for the consolidation of a thick layer of clay overlaid by a pervious layer of sand. The solution is based on the consolidation theory of Terzaghi, who solved the problem for one-dimensional consolidation. Author introduces the equations of Boussinesq to obtain the stresses in the three coordinate directions, and proceeds to solve the three-dimensional consolidation problem. This problem has, however, been treated by M. Biot [*J. appl. Phys.* **12,** 1941]. E. Vey, USA

1421. Hansen, V. E., Unconfined ground-water flow to multiple wells, *Proc. Amer. Soc. civ. Engrs.* **78,** Separ. no. 142, 18 pp., Aug. 1952.

Author attempts to express discharge for unconfined steady flow into a single well above an impermeable stratum in terms of boundary conditions at the well in order to get rid of the radius of influence in classic formulas.

From his own model experiments and re-examination of results of others, author obtained information about free surface near the well. Description of experiments is given.

Results of level measurements are all corrected to the case of no capillarity influence. Correction of the discharge for capillarity is not discussed. Near the well a linear relation was found between free surface level and logarithm of distance to well axis. This relation was used to fix by extrapolation the level of free surface beside the well.

Dimensionless graphical representations of empirical relations between discharge number and water levels in and beside the well are given. The discharge number, i.e., the discharge divided by the permeability coefficient and the square of the well radius, is shown to be the ratio of viscous and gravity forces. This number characterizes the shape of the cone of depression.

Author considers these results as indicative of the possibility of such an analysis and not as final solution of the problem, because available data are limited.

The concepts of well efficiency and effectiveness are discussed critically. Flow to multiple wells is merely mentioned, without analysis of experiments or theory. H. J. Schoemaker, Holland

1422. Jacob, C. E., and Lohman, S. W., Nonsteady flow to a well of constant drawdown in an extensive aquifer, *Trans. Amer. geophys. Un.* **33,** 4, 559–569, Aug. 1952.

A mathematical theory is given for a well of constant drawdown and varying discharge. The function involved is evaluated by numerical integration and a table of values given for use in applying the theory to field test data. The function is compared with other solutions; useful approximations are given. The method provides another valuable analytical procedure which supplements the Theis method now used where discharge is constant and drawdown varies. John C. Geyer, USA

1423. Lelli, M., Steady state in water-bearing strata with steep slope (in Italian), *Energia elett.* **29,** 7, 412–415, July 1952.

Excellent though brief analysis of important subject. More complete theoretical basis and variations are to be found in Muskat's "The flow of homogeneous fluids through porous media," New York, McGraw-Hill Book Co., Inc., 1st ed., 1937. J. M. DallaValle, USA

1424. Kolbuszewski, J., Electro-chemical hardening of clay, *Civ. Engng., Lond.* **47,** 553, 554; 556–558, 653–654; July, Aug. 1952.

Paper deals with the increase in bearing capacity of clay materials around and between electrode piles. Consolidation of clay by the process known as electroosmosis is described. The permanent nature of this consolidation is obtained by a "base exchange" which alters the character of individual clay particles and, in the case of aluminum piles, deposition of particles of aluminum hydroxide inside the clay structure.

Bearing capacity was assumed to be the load corresponding to a settlement rate of 10/10,000 in. per 30 sec by a special measuring pile. An increase in bearing capacity of over 500% was obtained for the clay tested. J. A. Cheney, USA

1425. Mills, K. N., Mechanics of cable tool drilling, *World Oil* **135,** 4, 123–129, Sept. 1952.

Article puts light upon a newer form of drilling motion introduced in cable-tool drilling. This method may be applied successfully in hard-rock formations.

Basically, the cable-tool-drilling process is a problem in vibration mechanics. The vibratory system consists of the drilling line and the tools attached to its lower end. In this system, the drilling line acts like a spring, and the tools constitute a mass attached to the free end of the spring. If the spring is reciprocating, the weight will reciprocate too. The distance traveled by the weight (drilling tools) increases as the frequency of drilling motion approaches the natural frequency of the drilling system.

The use of steel drilling lines has produced some changes in drilling practices, and it has dictated some major changes in the design of the drilling machine. To assure maximum drilling energy of the tools, the drilling cable must have sufficient elasticity, etc.

Article gives formulas for the determination of natural frequency and of the useful kinetic energy. The drilling energy increases directly with tool velocity. Further details of the mechanics of cable-tool drilling are also given, but it is not probable that it would also be very applicable for sample-boring purposes. Ch. Széchy, Hungary

Micromeritics

(See Revs. 1247, 1270, 1296)

Geophysics, Meteorology, Oceanography

1426. Kuo, H.-L., Three-dimensional disturbances in a baroclinic zonal current, *J. Meteor.* **9,** 4, 260–278, Aug. 1952.

In first part of paper, the equations of motion for large-scale atmospheric disturbances are expressed in novel coordinates. The vertical height coordinate is replaced by the potential temperature.

Later, the author carries out a thorough mathematical analysis of the stability, movement, and structure of disturbances in a baroclinic westerly current. He uses linearized perturbation equations, thus restricting the study to disturbances of small

amplitude. The study follows the general line of earlier investigations by Charney [title source, **4,** 135] and Eady [see AMR **3,** Rev. 2828]. Although the assumptions are slightly different (e.g., the omission of the stratosphere), the results confirm those of the earlier investigators and demonstrate that wavelike disturbances are possible in a baroclinic current, and that these correspond in wave length to wave cyclones and grow in amplitude at about the observed rate. The role of such disturbances in the large-scale transport of heat and momentum is also considered, and it is shown that they transport momentum downward and heat northward. The energy is shown to be derived from the horizontal pressure force in the lower part of the atmosphere. J. S. Sawyer, England

1427. **Bessemoulin, J., Confluence; diffluence. Convergence; divergence** (in French), *J. sci. Météor.* **4,** 14, 47–60, Apr./June 1952.

Paper consists of an exercise in manipulation of the continuity equation. Starting with the streamline field on the synoptic chart, the diffluence is defined as the degree to which any two streamlines separate in the downstream direction. It is pointed out that the horizontal velocity divergence is not necessarily positive when the streamlines diverge, since increases or decreases in speed must also be taken into account. An equation, which is an obvious consequence of the definitions, is derived relating diffluence and divergence, so that perhaps a simpler method for calculating horizontal divergence from synoptic charts is achieved. Most meteorologists will agree with reviewer that the problems in calculating divergence lie totally outside subject of present paper: They reside rather partly in the question of better wind measurements, and partly in consideration of what problems and what scales of motion are thereby to be investigated. Present paper contributes negligibly to meteorological research and concludes with a derivation and slight discussion of J. Bjerknes' tendency equation. Joanne Starr Malkus, USA

1428. **Platzman, G. W., The increase or decrease of mean-flow energy in large-scale horizontal flow in the atmosphere,** *J. Meteor.* **9,** 5, 347–358, Oct. 1952.

Employing the vorticity equation for nondivergent barotropic motion on a nonrotating earth, stability of the flow is investigated by a mathematical analysis which does not require small perturbations. In particular, the second time derivative of the energy of the mean flow in relation to the disturbed flow is studied. For plane Couette, plane Poiseuille, and profiles with flexes lying between fixed parallel boundaries, it is found that the initial energy transfer to or from the mean motion depends on the form and the wave length of the disturbed flow, and not merely on the nature of the mean motion. Among the more interesting results is the intensification of the jet in most cases which were examined and, for the cases studied, the fact that "equality of the mean speeds of propagation of the streamline and vorticity fields is a sufficient condition for the mean flow to remain unchanged (locally)." Lester Machta, USA

1429. **Halstead, M. H., The turbulent flux of heat and momentum from soil and water surfaces,** Proc. Sec. Midwest. Conf. Fluid Mech., Ohio State Univ. Press, 329–334, 1952. $6.

It is shown that, if the coefficient of turbulent transfer of a conservative property is assumed to be a linear function of height, it is possible to express the eddy flux as a function of the property at three heights, the exchange coefficient at the ground, and the height. Calculations of the heat flux during a single 24-hr period from this relation and from the continuity condition at the ground surface agree in order of magnitude and in the time at which major changes occurred. Similar results are obtained for eddy stress from a single observation of wind speed over a lake surface. Comparison of the results with those made by other assumptions is not made. R. G. Fleagle, USA

1430. Schönfeld, J. C., Propagation of tides and similar waves, Thesis, 's-Gravenhage, Staatsdrukkerij- en Uitgeverijbedrijf, 1951, 232 pp.

In a comprehensive treatment of tidal motion in estuaries, author begins with elementary treatment of wave motion to clarify subsequent discussion on limitations of simplified wave theory. Analogy with electrical nonhomogeneous transmission line is applied to cases of wave motion in long deep canal, and "impedance" is borrowed from electric theory and applied to analysis of tidal waves. However, basically, analysis follows classical procedures. Book includes a valuable review of theory of partial differential equations needed in treatment of subject. It introduces into mathematical analysis the "characteristic" conception as distinct from the usual "harmonic" conception as applied to wave motion. The characteristic conception is an extension of Cauchy's problem in linear partial differential equations so well discussed by Hadamard ("Leçons sur le propagation des ondes").

Following cases are discussed: (a) Positive and negative total reflection, (b) partial reflection, (c) canal with one end open and other closed, (d) canal with both ends open, and (e) canal with both ends closed.

A few simple laboratory experiments are discussed, and a rather detailed analysis of results is given. Of interest is the outline of harmonic and characteristic computation techniques. The latter is, perhaps, the only one available in English language.

Work is well printed and edited and contains many excellent cuts and charts. Investigation is, perhaps, the best one published on tidal wave motion in many years and should serve as starting point for future research. J. M. DallaValle, USA

1431. Bowden, K. F., and Fairbairn, L. A., A determination of the frictional forces in a tidal current, *Proc. roy. Soc. Lond.* (*A*) **214,** 1118, 371–392, Sept. 1952.

Frictional stresses are computed from a harmonic analysis of measurements of tidal heights and currents in 20 meters of water in Irish Sea. Method requires high precision from difficult shipboard observations to achieve even order of magnitude results. General agreement with previous estimates.

H. Stommel, USA

1432. Malkus, W. V. R., and Stern, M. E., Determination of ocean transports and velocities by electromagnetic effects, *J. Marine Res.* **11,** 2, 97–105, 1952.

Useful integral theorems are developed for determination of transport of ocean currents from potential measurements at the top surface, potentials due to induction in water moving through earth's magnetic field. Article is a generalization of theoretical results obtained before in only special cases.

Henry Stommel, USA

1433. Worsley, Beatrice H., On the second-order correction terms to values of gravity measured at sea, *Proc. Camb. phil. Soc.* **48,** part 4, 718–732, Oct. 1952.

Article discusses results of numerical integration study of equations of motion of the Vening Meinesz pendulum on oscillating support. Integration was carried out on EDSAC, electronic computing machine (digital) of Cambridge. Second-order correction terms mentioned in title refer to horizontal and vertical accelerations.

Novel result obtained is that, under typical conditions, horizontal acceleration correction is probably more than double that found analytically by Browne. Vertical acceleration correction, however, is found to agree with Browne's results over wide range of accelerations. W. R. Griffin, USA

1434. Sherman, L., On the scalar-vorticity and horizontal-divergence equations, *J. Meteor.* **9,** 5, 359–366, Oct. 1952.

For certain types of atmospheric motion, it is not sufficient to study the vorticity fields only, but it is both necessary and useful to study the field of horizontal divergence as well. This is connected with the vertical motions of the atmosphere. Therefore, the equation of the horizontal divergence is derived, and the physical meaning and the order of magnitude of the terms involved are discussed. Horst Merbt, Sweden

1435. Frenkiel, F. N., Application of the statistical theory of turbulent diffusion to micrometeorology, *J. Meteor.* **9,** 4, 252–259, Aug. 1952.

Some concepts of the statistical theory of turbulence (scales of time and space, mean values, correlations, turbulent viscosity) were applied to turbulent diffusion problems in meteorology. It was shown that the turbulent viscosity is a function of the dispersion time, and can be expressed as a function of the variance of the turbulent velocities, and of the Lagrangian correlation coefficient. The concentration distribution, as a result of turbulent diffusion, is studied on the basis of this relation. For large dispersion time, the turbulent viscosity becomes independent of time; hence, the concentration takes the Gaussian distribution as a solution of Fick's law. In the general case, the turbulent viscosity varies with time, and the concentration cannot be determined by Fick's law. Various properties of the turbulent viscosity are discussed from different expressions of the correlation coefficient. Applications are made to the study of the dispersion of a spherical cloud and the dispersion from a continuous point source. C. M. Tchen, USA

1436. James, R. W., The latitude dependence of intensity in cyclones and anticyclones, *J. Meteor.* **9,** 4, 243–251, Aug. 1952.

A statistical study is made of the central pressures and masses of cyclones and anticyclones in U. S. and Australia. Four years of U. S. data and one of Australian data show that the departure of central pressure from mean pressure increases with latitude. It is suggested that the mean mass and the mean kinetic-plus-potential energy of anticyclones is approximately independent of latitude. Author points out that the value of the study depends on its application to further study of the relations between isobaric configurations and the energy of cyclones and anticyclones. R. G. Fleagle, USA

1437. van Meel, D. A., Calculation of the error in the determination of the relative humidity caused by inaccuracies of the measurements of temperature with the wet- and dry-bulb thermometers and the inaccuracy of the constant, occurring in the psychrometer equation (in Dutch), *Ingenieur* **64,** 35, Ch.85–Ch.88, Aug. 1952.

Making use of an equation of the Antoine type $p = e^{A-B/T}$ for the vapor pressure of water, an equation is derived by differentiating the psychrometer equation, thus making possible the calculation of the accuracy of the measurement of the relative humidity resulting from the accuracies of the thermometer readings and of the constant occurring in the psychrometer equation.

Tables and a diagram are given, permitting a rapid determination of said accuracy for a given wet- and dry-bulb hygrometer. From author's summary

1438. Wylie, R. G., and Harper, A. F. A., The accurate control of relative humidity, *Austral. J. appl. Sci.* **3,** 3, 219–227, Sept. 1952.

A method and apparatus are described for the control of humidity by means of which the relative humidity in a closed cabinet can be controlled with an accuracy of ±1%. The relative humidity can be controlled independently of the cabinet temperature, or made to depend on cabinet temperature in a predetermined manner. From authors' summary

Lubrication; Bearings; Wear

1439. Murray, S. F., and Johnson, R. L., Effects of solvents in improving boundary lubrication of steel by silicones, *NACA TN* 2788, 23 pp., Sept. 1952.

Lubricants for aircraft turbine-engine bearings must have viscosity-temperature curves flat enough to allow pumping at −65 F and still provide lubrication at over 300 F. Available petroleum lubricants are not satisfactory. Silicones can have proper viscosity and thermal stability, but are poor lubricants. Authors verified hypothesis that addition of 30 to 50 volume per cent solvents to silicones permits formation of adsorbed surface films which reduce friction and prevent surface failure.

Friction between loaded steel ball and rotating disk was measured under boundary lubrication with DC 200 silicone, to which had been added various percentages of benzene, cyclohexane, tetralin, toluene, methylcyclohexane, methyl-ethyl ketone, carbon tetrachloride, di(2-ethyl-hexyl) sebacate, or di(2-ethyl-hexyl) adipate. In each case, there was some optimum concentration for best lubricating effectiveness. The diesters (33% by volume in silicone fluid) gave viscosity-temperature characteristics similar to silicone alone, and may be practical lubricants. E. M. Simons, USA

1440. Eisele, E., Damage (false Brinelling) to stationary roller bearings when subject to vibration (in German), *Motortech. Z.* **13,** 8, 200–205, Aug. 1952.

After a review of previous work on "fretting corrosion," "false Brinelling," or "friction oxidation," author describes experiments in which elements of a ball bearing are subjected to oscillating forces. The degree of damage was estimated from measurements of the major and minor axes and the depth of the pit developed in the race element. The inner element of an assembly in which four balls are held in a cage between inner and outer races is mounted on a table which is vibrated with an amplitude of 0.3 mm at frequencies ranging from 2000 to 10,000 cpm. The magnitude of the pulsating force at the points of contact was varied by changing the value of a dead weight carried by the outer ring of the assembly. The damage produced in the test closely resembled that encountered in practice, and it is shown that damage increases continuously with number of reversals and extent of loading. Reduction in interference fit and increase in radial clearance caused increase in damage up to radial clearances of 15μ, but above this the effect was not marked.

While author admits that a complete cure is not available, he claims the following measures would considerably reduce the extent of damage: (1) Reduction of pressure between ball and race by using larger balls or substituting needle or roller bearings. Reduction of dynamic loading by damping or avoidance of resonance. (2) Provision of the best possible protection of the pressure area from chemical influence such as oxygen and moisture and use of acid-free lubricants. Oil provides better protection from atmospheric influences than grease. (3) Preloading may be beneficial in certain circumstances. (4) A fine finish of the races permits a certain limited improvement. F. T. Barwell, Scotland

1441. **Bearings, lubricants, and lubrication. A digest of** 1951 literature, *Mech. Engng., N. Y.* **74,** 11, 885–891, Nov. 1952.

1442. **Gottwald, F., and Wesp, A., The rocking bearing as instrument bearing with low friction** (in German), *Z. angew. Phys.* **3,** 9, 345–348, Sept. 1952.

A shaft is carried in a ball bearing, the outer race of which is in turn carried by the inner race of another ball bearing. The outer race of this latter bearing is fixed in space. Authors consider the effect on the frictional resistance to rotation of the shaft when an oscillating movement is applied to the intermediate member (inner race of outer bearing attached to outer race of inner bearing). It is shown analytically that, taken over a complete cycle of operation, the net frictional drag on the shaft is zero at zero speed and that benefit persists as speed is increased up to a certain value, depending on the frequency of oscillation. The effect is confirmed experimentally, and viscous lubrication is shown to increase frictional drag. Application to reduction of the effects of friction in servomechanisms is envisaged.

F. T. Barwell, Scotland

1443. **Du3cis, G. B., and Ocvirk, F. W., Experimental investigation of eccentricity ratio, friction, and oil flow of short journal bearings,** *NACA TN* 2809, 79 pp., Nov. 1952.

There is a scarcity of good experimental data to check the many existing sleeve-bearing theories. Present paper is a step in this direction.

Performance of 1.375-in.-diam bearings with l/d's of 1, 1/2, and 1/4 are measured at speeds to 6000 rpm and loads to 900 psi. Data on eccentricity ratio and friction for all bearings fall on single curve when plotted against Sommerfeld number times (l/d) squared. Method of generalizing oil flow data is demonstrated. Methods of obtaining maximum bearing temperature and evaluating effect of shaft deflection or misalignment are also discussed. Corrected data show good agreement with short-bearing theory.

Reviewer believes verification of theory and use of generalized curves provide a valuable tool to bearing designers.

E. M. Simons, USA

1444. **Chaplígin, S. A., Collected works, vol. III. Mathematics and mechanics [Sobraniye sochinenií, T. III. Matematika i mekhanika],** Gos. Izd. Tekh.-Teor. Lit., 1950, 467 pp.

This volume contains a series of technical articles on the fluid friction of a very viscous lubricant between two eccentric circular shafts, the form drag of parabolic projectiles in cavitational incompressible plane flow, the dynamics of gas flow in a gun barrel, the flow of water in "hydrocones" (turbine exhausts with solid cores), cascade problems, secondary flow problems; also on some problems of elasticity (eccentric tube under constant pressure, plane deformation problems, etc.), and rigid dynamics problems; several of these had not been previously published. All display outstanding mathematical ingenuity allied to a physical intuition which is sometimes at fault in formulating problems. There are also a collection of speeches, a biographical sketch, and evaluations of Chaplígin's work in various fields, written by leading Soviet scientists.

Leon Trilling, USA

1445. **Lane, T. B., and Hughes, B., A study of the oil-film formation in gears by electrical resistance measurements,** *Brit. J. appl. Phys.* **3,** 10, 315–318, Oct. 1952.

In pursuit of information concerning the nature of lubrication in gears, measurements of the electrical resistance between the meshing teeth of rotating gears have been made, using a cathode-ray oscillograph. Photographs of the trace on the screen of the cathode-ray oscillograph are shown indicating values of resistance ranging from infinity to zero. The variation of resistance depends on the load, though the resistance is always lowest where the sliding speed is highest and has its maximum value in the neighborhood of the pitch-line where there is no sliding motion. Absolute values of film thickness could not be determined.

From authors' summary

1446. **Giovannozzi, R., The pitting phenomenon and the theory of gear lubrication** (in Italian), *Monogr. Lab. Aero. Politecn. Torino,* no. 279 = *Atti Rassegna Tecn. Soc. Ingegn. Archiit. Torino* (*N.S.*) **5,** 7, 7 pp., July 1951.

Gears are designed either on the basis of the bending strength of individual teeth or by checking stress concentrations at the contact of teeth (calculation of wear). These design methods neglect the effect of the lubricating agent. The presence of a lubricating film affects the stress concentrations and the strength of teeth to a marked extent, as evidenced by pitting which only occurs in lubricated gears (Way's experiments).

Author endeavors to explain the experimental results concerning pitting by the theory of lubrication. As he points out, the theory can pretend to give only a qualitative explanation; the unit pressures being very high, the lubricating film is extremely thin (less than a micron). Thus, the hydrodynamic theory of lubrication is, at best, only an approximation. Moreover, a more accurate theory should take the surface strains into account. The theoretical results obtained explain certain experimentally observed facts (the experiments of H. Glaubitz) and indicate the approach which should be adopted in future experiments aimed at giving a complete explanation of pitting.

S. Casacci, France

1447. **Lloy, J. M., Literature survey of the effect of sub-zero temperature on fuels and lubricants,** *Nat. Res. Counc. Canada Rep.* no. MP-9, 186 pp., July 1952.

1448. **Bowden, F. P., The influence of surface films on the friction and deformation of surfaces,** Symp. Proper. metall. Surf., Institute of Metals, 197–212, Nov. 1952.

Paper is an exposition of the facts of a large variety of surface films on sliding of both metals and nonmetals. It bears out the statement that friction and damage are influenced more by these films than by the materials themselves.

Degassed metals seize when slid and indicate coefficient of friction over 100. Small amounts of gases adsorbed on surface greatly reduce friction and damage. Similar effect is observed with nonmetals, but of smaller magnitude. Other surface conditions reduce wear but not necessarily friction. Relative hardness of oxide and base metal determines effectiveness of this film. Hard oxide on soft base such as tin and aluminum breaks under light load. Hardened Beilby layer of polished surface provides similar protection. Pronounced reduction in wear with boundary lubricants is shown to be result of solid metallic soap formed on surface. These are not effective beyond the melting point of the soap. Chlorine and sulfur are not effective below temperatures which will cause attack of the surface. Low shear-strength films such as indium, molybdenum, disulfide, and polytetrafluorethylene may also be interposed to prevent damage to sliding surfaces.

Reviewer believes such fundamental understanding of the mechanism of prevention of damage to be especially valuable when considering problems involving sliding surfaces.

J. B. Bidwell, USA

1449. **Tabor, D., The mechanism of rolling friction,** *Phil. Mag.* (7) **43,** 345, 1055–1059, Oct. 1952.

Paper is preliminary report of work on forces involved in rolling

contacts. Results may be applicable to ball and roller bearings. Experimental work was performed by rolling single steel ball between two loaded parallel plates of softer material. With flat plates, initial traverse produces plastic deformation resulting in groove. Successive traverses cause increase in groove width which approaches a constant value. Principal conclusion is that no slip occurs in the contact area. It is postulated that all losses are the result of hysteresis of the materials. Conclusion is substantiated by (1) absence of reduction in friction by boundary lubricants, and (2) correlation of experimental data with calculated losses for steel ball rolling on rubber.

Reviewer believes that results may be applicable to balls or rollers on flat plates at moderate loads. It is difficult to conceive that sufficient tangential elastic deformation can occur to prevent slip in the case of a heavily loaded ball in a close fitting race. In this case, the contact occurs at points widely different in distance from the axis of rotation of the ball. Deformations necessary to avoid slip would exceed elastic limit. Slip would be expected to occur if tangential stress exceeds frictional force. Existence of slip in deep-groove ball bearings is evidenced by wear except on two circumferential nonslip bands found after long running at constant load. J. B. Bidwell, USA

1450. Shooter, K. V., and Tabor, D., The frictional properties of plastics, *Proc. phys. Soc. Lond. (B)* **65,** part 9, 393B, 661–671, Sept. 1952.

Paper compares the frictional properties of certain plastics such as polyvinyl chloride, polyethylene, polytetrafluorethylene, nylon, and polymethylmethacrylate with those of metals, considering plastic deformation of the materials during welding. It is found that friction behavior of plastics is similar to that of metals. With metals, cold welding occurs at the area of immediate contact, and friction and force are required to shear these junctions. With plastics, strong adhesion occurred and shearing takes place within the softer metals.

Of particular interest is the difference in the frictional behavior of polytetrafluorethylene and other plastics. Adhesion is small and friction is low. E. I. Shobert, II, USA

Marine Engineering Problems

1451. Blackman, R. V. B., edited by, Jane's fighting ships 1952–53, London, Sampson Low, Marston & Co., Ltd., 1953. £4.40.

1452. Monk, J., Thomas, L. I., and Atkinson, C. C., Recent developments in naval propulsion gears, *Soc. nav. Arch. mar. Engrs.*, 33 pp., Nov. 1952.

1453. Tasseron, K., Results of systematic tests of ship propellers with single adjustable blades (in Dutch), *Schip en Werf* **19,** 14, 294–303, July 1952.

For the model of a vessel of 300 hp at 250 rpm, three propellers with adjustable blades, which differ in the design speed, are investigated. Results of propulsion tests for each propeller are given over a range of blade settings. Conclusions for the design speed of an optimum propeller with adjustable blades (which depends on the type of vessel) are made.

H. W. Lerbs, USA

1454. Marstrand, J., Methods of hydrodynamic computation of ship propellers, *Trans. Dan. Acad. tech. Sci.* no. 1, 112 pp., 1952.

After a summary of the evolution of the ideas on the subject, and a thorough discussion of all known factors in the computation of ship propellers on the basis of lift and drag coefficients determined for airfoils of various shapes, author calculates the characteristics of two existing propellers and checks them with the measured results of experiments performed in the Gothenburg Swedish State Experimental Tank. The discussion gives a useful contribution to the calculation of the optimal propeller for a given case, which is gaining ground in the practical design of ship propellers. R. Spronck, Belgium

1455. Davies, J. B., The strength of ships' derricks, *Trans. Instn. nav. Arch. Lond.* **93,** 23–32, 1951.

Paper gives elementary calculation of forces on ship's derricks, including influence of weight, guys, and bending moment due to eccentricity of resultant of forces in cargo runner and span tackle. "Union purchase" system is also considered, but not influence of preventer guy. Crippling load is calculated on base of Euler load for constant moment of inertia, including influence of average initial crookedness. Influence of reduction of moment of inertia toward ends is not considered. Bending is considered separately on base of "stress factor" equal to 3.5 and not as eccentricity, influence of which might have been added to influence of initial crookedness. Secondary buckling deciding minimum allowable thickness of hollow boom is not considered.

Georg Vedeler, Norway

1456. Pimlott, J. R., The TMB torsionmeter shaft system, *David W. Taylor Mod. Basin Rep.* 825, 27 pp., July 1952.

The design and development of a unique torque-measuring system for use during full-scale tests of naval vessels are described. The system consists of a 6-ft section of shafting, especially designed for use with a new torsionmeter, and a special calibration stand for statically load-calibrating the torsionmeter shaft with the torsionmeter. Carefully planned calibration techniques integrate these components into a highly accurate torque-measuring system that has been adopted by the Bureau of Ships for inclusion in new naval vessels. From author's summary

1457. Jasper, N. H., Measurement of hydrodynamic loads on a high-speed motor boat caused by wave impact during rough-water trials, *Proc. Soc. exp. Stress Anal.* **8,** 2, 83–89, 1951.